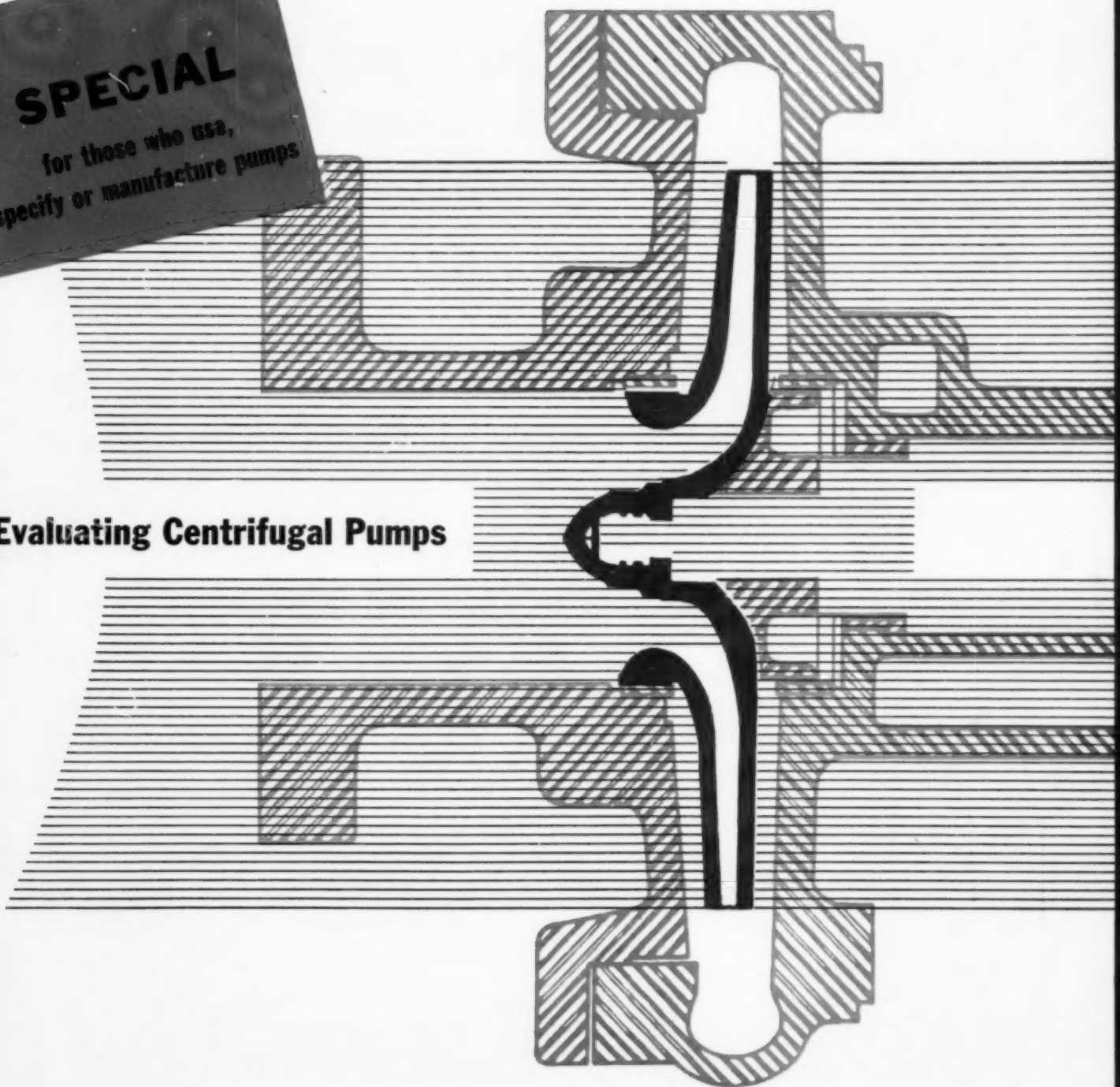
Chemical Engineering Progress

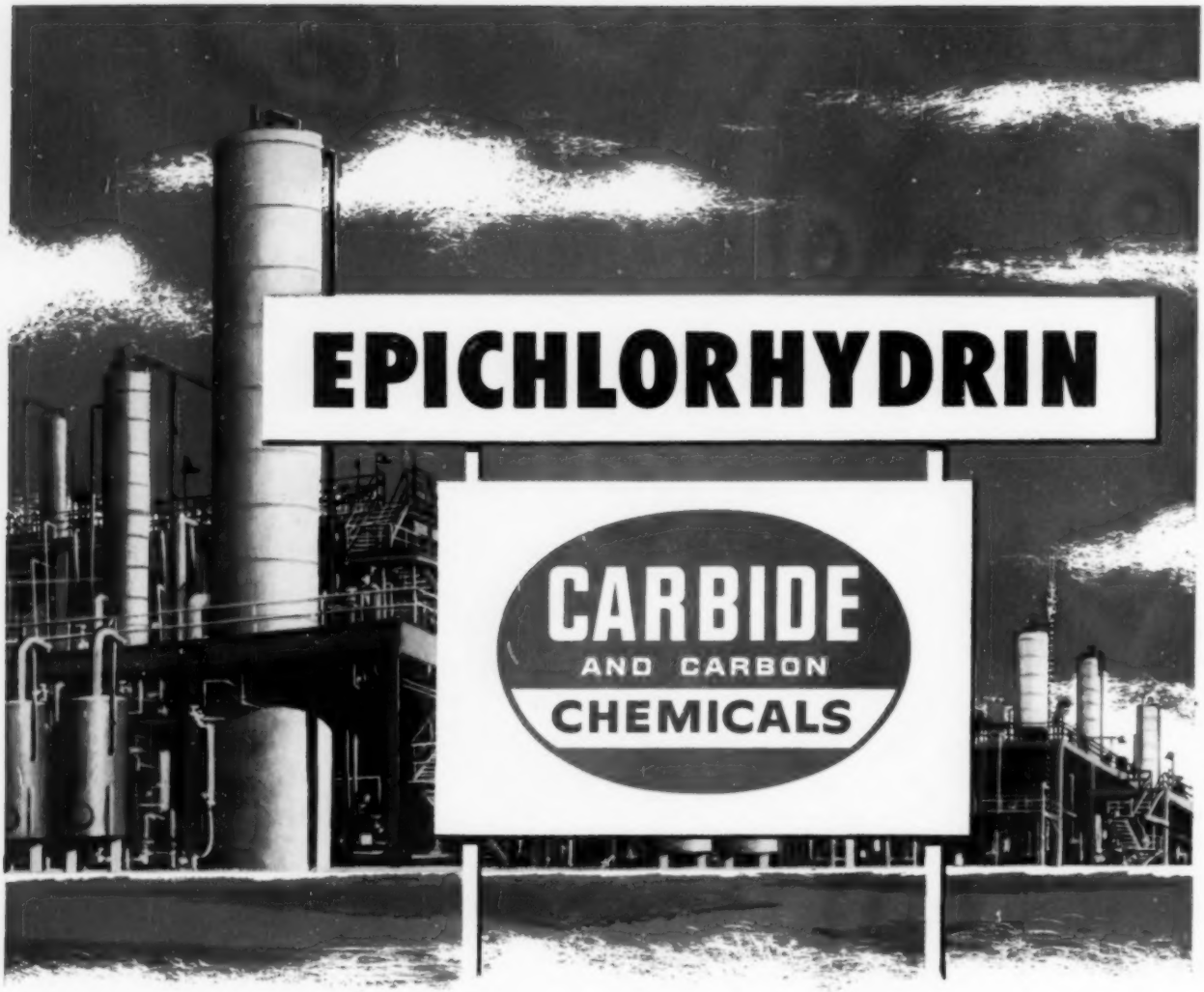
MAY 1955

SPECIAL
for those who use, specify or manufacture pumps



Evaluating Centrifugal Pumps

also: your public · extractive rendering · depreciation · distillation · silicones · hydrochlorinated styrene · mulling



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That's not all— in addition to epichlorhydrin, Carbide and Carbon offers ethylene chlorhydrin and propylene chlorhydrin in commercial quantities for chemical syntheses.

Chemical Engineering Progress

MAY, 1955 • Volume 51, No. 5

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this month's cover

The difference between an ordinary centrifugal pump and the one depicted on the cover is that the latter's stresses are shown. For further details see page 207.

—cover by Milton Wynne Associates.

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For a brief description of each article . . . see "What's In This Issue"—page 35

Better Sifting Better Grading
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- **Clean, Thorough Separations**
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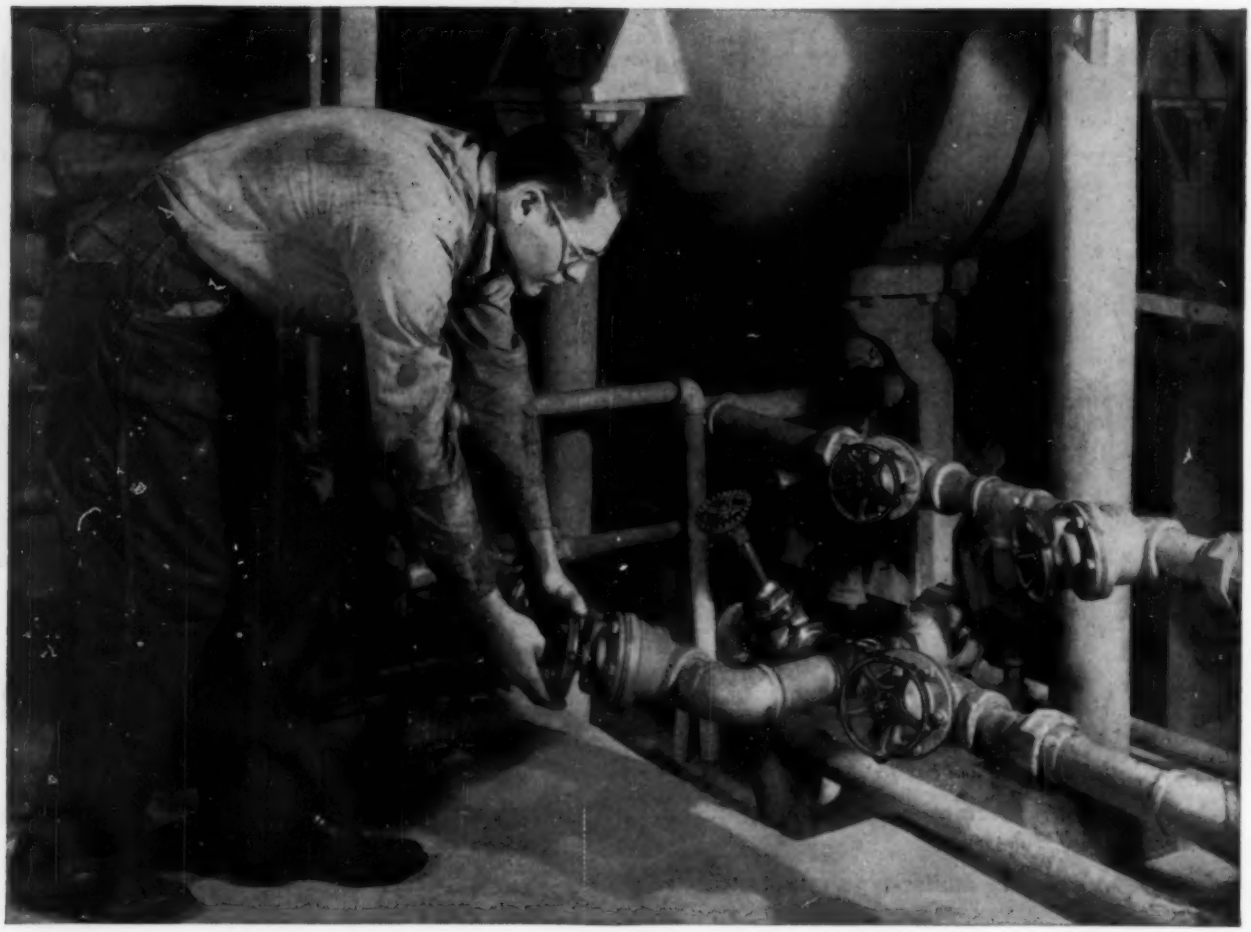

Heavy fluids can't hinder working parts in these CRANE VALVES

THIS CASE HISTORY tells how the United States Playing Card Co., Cincinnati, solved—with Crane Diaphragm Valves—a costly problem of piping heavy enamels for paper coating.

The trouble was in the plug cocks and conventional gate valves formerly used in the enamel lines. During normal shutdowns the heavy liquid would build up on seating surfaces, in stem threads and working parts. The cocks and gates would "freeze up" . . . were hard to operate . . . couldn't be shut tight. The condition hampered production . . . made floors messy and dangerous . . . pushed maintenance costs sky-high.

Replacing with Crane Packless Diaphragm Valves stopped the trouble completely. Their sealed-to-fluid bonnet and pliable neoprene disc insert did the trick. After more than 4 years, all 48 Crane valves installed—with no maintenance whatsoever—are still seating tight . . . still operating freely and smoothly.

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Working parts are safely out of contact with line fluid. The diaphragm seals the bonnet—that's all it does, giving it longer life. The independent disc with pliable insert seats tightly on foreign particles or seat deposits . . . and controls fluid, even should diaphragm fail. See your Crane Catalog or Crane Representative for wide selection of body, bonnet, and trim materials in these valves for countless uses.

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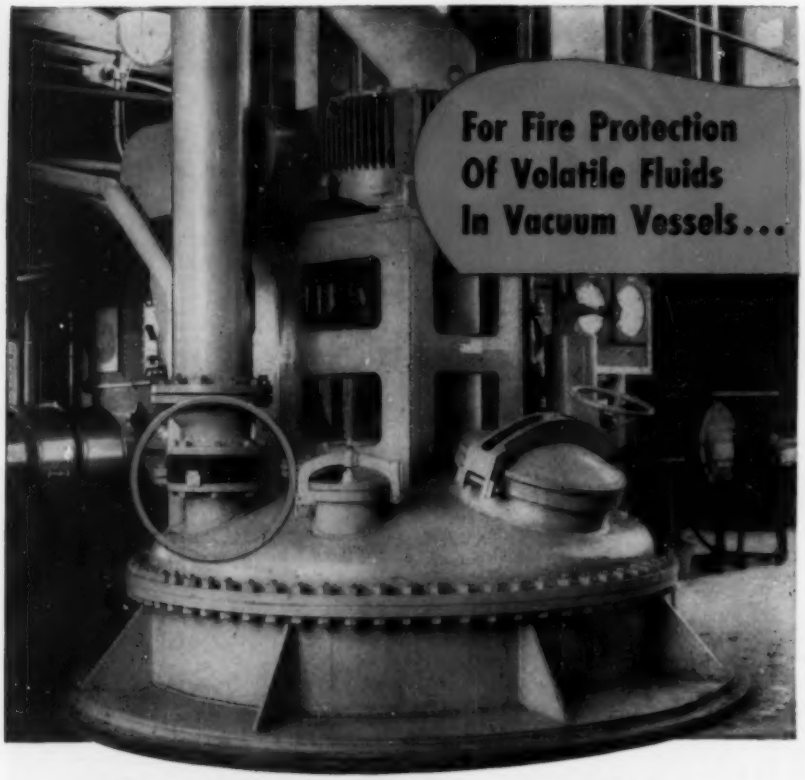

The Formica Company Uses

BS&B SAFETY HEADS!

In the Formica Company's Evendale, Ohio, plant are four large high-vacuum vessels used for the impregnation of basic raw material with resins and varnish. These substances are, of course, even more volatile in a partial vacuum than at atmospheric pressure, and a single spark could set them off.

To protect each vessel from explosive destruction in case ignition of its contents *does* occur, an 8-inch BS&B SAFETY HEAD is utilized. This SAFETY HEAD acts as a *controlled* weak spot in the vessel, and would fail *safely*, with minimum danger from fire, at a lower pressure than the vessel itself.

Future plans of the Formica Company call for additional resin processing vessels, and they too will be protected with BS&B SAFETY HEADS!

If you aren't already using BS&B SAFETY HEADS in *your* plant to safely handle pressure relief problems, we'd suggest you get in touch with your nearest BS&B Representative without delay. Or, write for Catalog and full information... no obligation!

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For Better Regulation of Pressures, Temperatures, Liquid Levels or Flow, Equip Your Process with BS&B AUTOMATIC CONTROLS!

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An Opinion on Relocation

In regard to the current discussions involving the unification of the five engineering societies, I would like to make the following points:

1). I am in favor of any attempt of the A.I.Ch.E. to join with the four engineering societies and become part of a new engineering society. In the March issue of Chemical Engineering Progress, Mr. Kirkbride said that it would be a serious error for the A.I.Ch.E. to buy equity in U.E.T. if it does not relocate. I feel that we should join the four combined societies regardless of whether they relocate or stay in their present office. It appears that we will have to match the equity of U.E.T. regardless of the course of action. I also feel that more than $10 per member should be asked (or assessed) for this purpose; certainly a minimum of $30 would not be too much.

2). I would like to go on record as favoring a New York location for the combined engineering societies.

Flushing, New York

JOHN E. WYLIE

A National Security Problem for the Chemical Engineer

S. P. Smith's paper, "Selecting Plant Sites," in the March 1955 issue, is a comprehensive and logical study of the significant factors in site selection and outlines a sound procedure for their application. Considering the state of the world we live in today, however, it seems to me that it omits one important factor—dispersion in the face of the possibility of nuclear attack.

. . .

No one questions that economic factors must necessarily carry the greatest weight in plant site decisions. Certainly though, dispersion should be considered, particularly in deciding among potential sites of relatively similar economic desirability. The possibility of rapid tax amortization advantages based on dispersed location of an essential plant is also relevant. Finally, management might well ask itself, "Should we sacrifice some economic advantage to increase the probability that we will still have a plant to operate, after a nuclear attack?"

It seems to me that chemical engineers,

(*Continued on page* 16)

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Nickel-base alloy stops unscheduled shutdowns

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Meet some valves that show exceptional corrosion-resistance. They are made of HASTELLOY alloy D, a high nickel-base alloy.

A large oil refinery installed these valves in plants that process and concentrate sulphuric acid, which, in turn, is used for producing isopropyl and ethyl alcohol and ethers.

And here's what this user writes:

"At present, the units are on a four-month scheduled inspection and repair interval. HASTELLOY *alloy D fittings are the only ones available that do not require unscheduled shut downs for replacement and accompanying loss of production between these inspections.*

Scores of users report similar savings where equipment is exposed to strong corrosives.

You, too, may obtain excellent results by using one of the series of nickel-base alloys produced and sold under the trade-mark "HASTELLOY" by Haynes Stellite Company, Kokomo, Indiana, a Division of Union Carbide and Carbon Corporation.

Whatever your corrosion difficulty, make use of our wide practical experience. Send details of your problem for our suggestions. Write us today.

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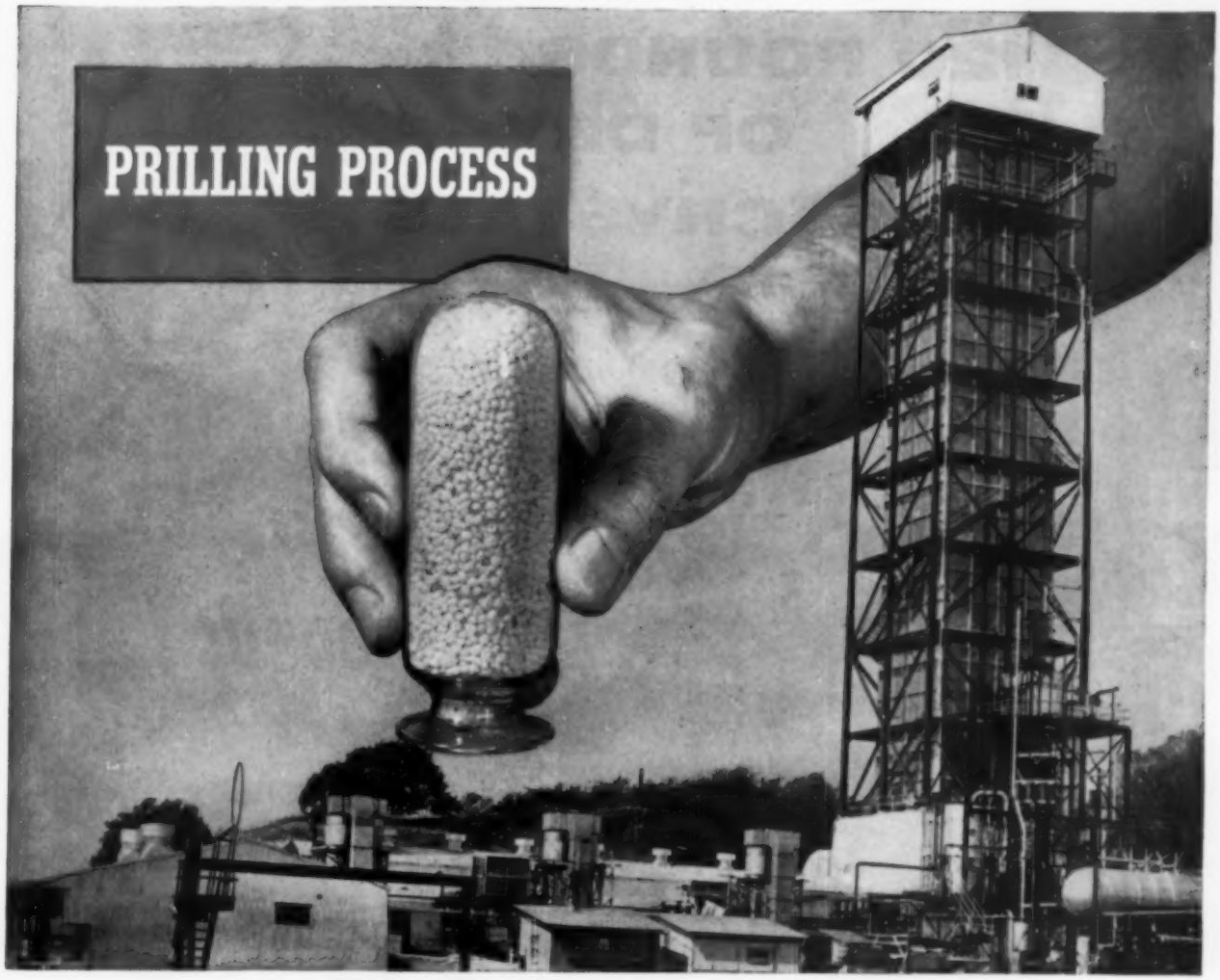

GIRDLER plant converts nitrate solution into granules

THIS IS PART of the ammonium nitrate plant of Cooperative Farm Chemicals Association, Lawrence, Kansas . . . engineered and built by Girdler. Concentrated solution of ammonium nitrate is sprayed in the top of the prilling tower at the right into a countercurrent stream of air. As the ammonium nitrate falls, it forms into a granular salt. These prills are then dried, coated with clay and bagged as fertilizer . . . ready for the farmer to use in his spreader.

The Girdler Prilling Tower is just one phase of the *complete plant service* offered by Girdler in the field of ammonia, nitric acid and ammonium nitrate facilities. This prilling process has other possible applications. Perhaps there's an idea here for *your* product. We'd be glad to help you explore this. Just call our nearest office.

GIRDLER DESIGNS processes and plants

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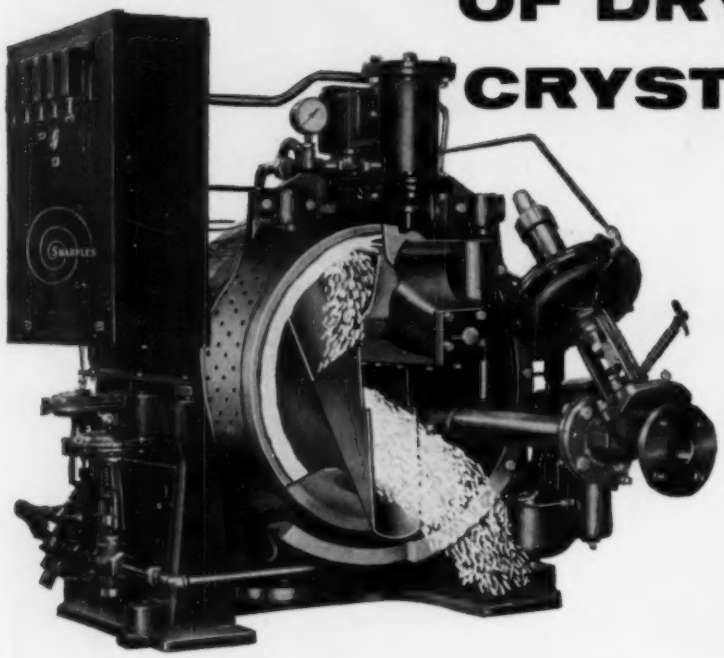

Every 27 Seconds!

The Sharples Super-D-Hydrator is giving this kind of performance day in and day out—and crystal moisture is held to well under 2%.

The remarkable efficiency of this centrifuge results from the combination of high centrifugal force, the relatively small unit load of crystals that is handled very rapidly and continuously, adjustable cyclic operation, and rugged corrosion-resistant construction to withstand the most rigorous service.

The Super-D-Hydrator offers complete flexibility of control to obtain optimum performance . . . any part of the cycle may be adjusted while the centrifuge is in operation . . . as many as 3 different rinsing media may be applied to the crystal cake, independently . . . mother liquor and rinses can be kept separate through the use of special "diversion valves" . . . automatic protection against unbalance and overloading is "built-in".

Available in two sizes, the Super-D-Hydrator is setting new standards in crystal dehydration efficiency and consistent uniformity of product.

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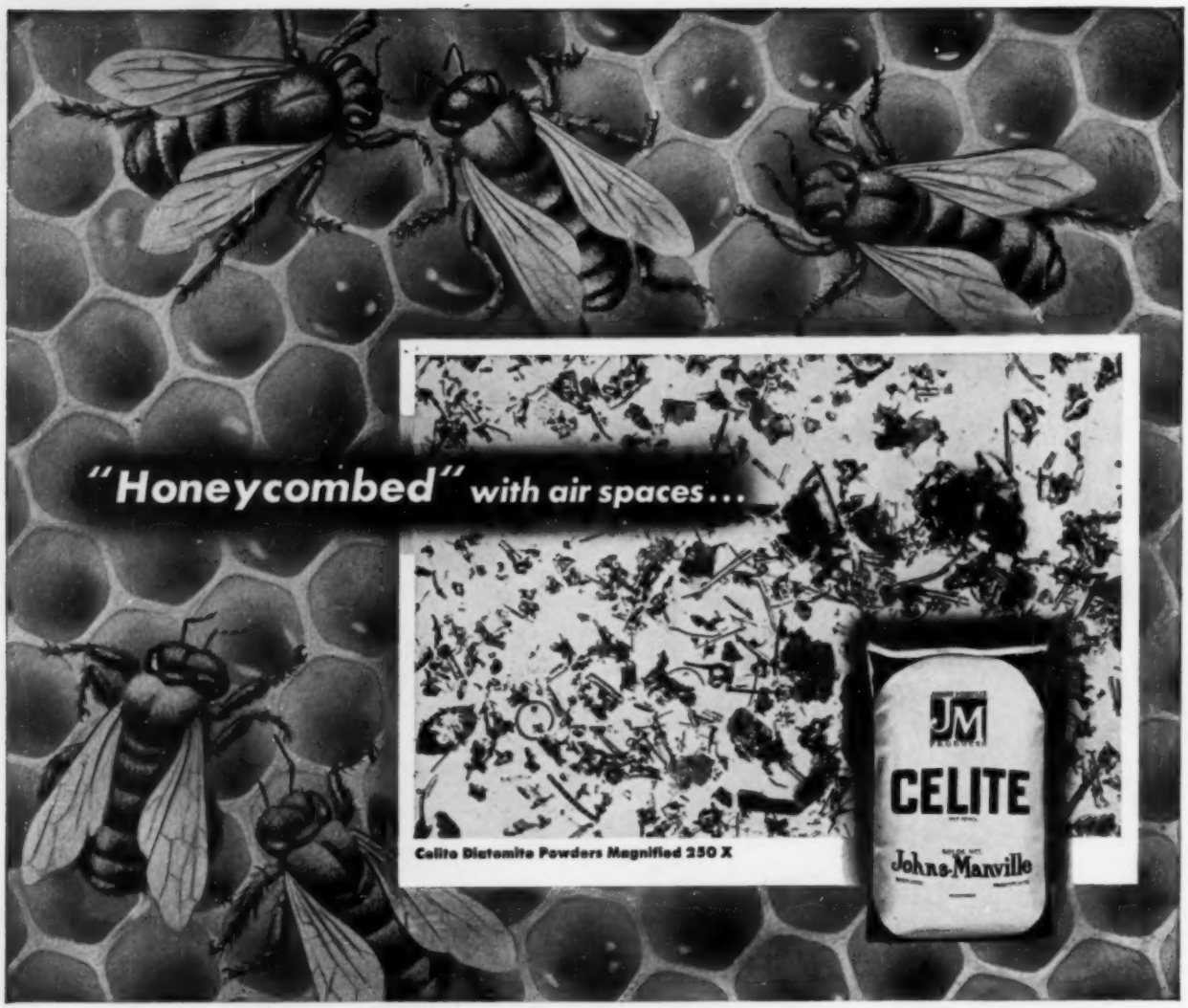

Celite Powders provide bulking action

3 to 10 times greater than any other inert mineral filler

POUND FOR POUND, Celite* diatomite powders supply more bulking action than any other inert mineral filler because their cubic volume is 3 to 10 times greater. Celite's unique "honeycombed" structure is composed of microscopic, irregularly shaped particles that won't pack down. In mass they weigh only about 10 lbs. per cubic foot.

That's why Celite is so widely used to add bulk and body to industrial formulations. For example, it extends white pigments in paints and papers . . . it improves dispersion of insecticides and fertilizers . . . it fluffs up dry powders such as household cleansers.

Also, from Celite's "honeycombed" structure comes its great absorptive capacity. This characteristic is profitably utilized to keep powders free-flowing . . . to provide a medium for shipping or storing liquids in dry form. And because of the physical structure of its individual particles, Celite has become the outstanding flatting agent for paints . . . it serves as a mild, non-scratching abrasive for fine polishes . . . it improves the surface appearance of plastics.

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- Workability — readily fabricated and serviced in the field
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- Complete technical service

Manufactured Only By National Carbon Company

"Karbate" impervious graphite is a "must" in many highly corrosive services. But these applications only begin to measure the possibility of savings offered by "Karbate" products in a wide range of process locations. Wherever corrosion, contamination or thermal shock must be eliminated, "Karbate" products save time and money all the way down the process line.

WRITE FOR LITERATURE!

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Corrosioneering News

Quick facts about the services and equipment Pfaudler offers to help you reduce corrosion and processing cost.

Published by The Pfaudler Co., Rochester, N.Y.

CORROSION GUARANTEE ANNOUNCED!

Now—a year's corrosion guarantee on Pfaudler vessels used in processes containing hydrochloric acid!

If your product has hydrochloric acid as its principal corrosive agent, and you operate in the range represented by the darkest area on our chart, you can now have processing equipment which carries a full year's guarantee against corrosion!

If chemical attack should render your Pfaudler glassed steel equipment unusable within its first year of use under the operating conditions specified in the guarantee, Pfaudler will replace or repair it without charge by on-the-spot methods or on an F.O.B. factory basis.

You receive this guarantee on all glassed steel equipment supplied with Pfaudler acid-alkali-resistant glass, when it is expressly purchased for processing hydrochloric acid in the specified range of conditions. Such equipment includes reaction kettles, stills, receivers, condensers, heat exchangers and storage tanks.

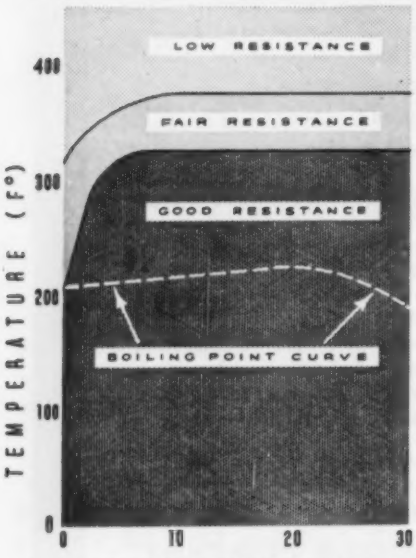
The guarantee, in written form, is delivered with the equipment, and states clearly the operating conditions under which it applies.

You'll find three important advantages in this unique guarantee:

1. It minimizes the possibility of major shutdowns caused by corrosion of equipment.
2. It frees you from large maintenance or replacement costs.
3. It assures you that the glassed steel equipment you buy is *matched to your process,* selected for its special resistance with reference to *your* product.

Perhaps you have a problem right now, for which this guaranteed corrosion-resistant equipment offers a solution. Call in your Pfaudler representative and discuss your needs with him.

Or write for Bulletin 205, "Glassed Steel—Its Resistance to 92 Corrosives, Forms Available and Applications."



Corrosion resistance of Pfaudler acid-alkali-resistant glass by hydrochloric acid. For concentrations and temperatures in darkest area, glassed steel equipment is guaranteed against corrosion. In the "fair resistance" and "low resistance" areas, Pfaudler glassed steel may often be the most resistant material of construction available to you at *reasonable* cost. To make this decision, Pfaudler should be consulted, and tests may be run in either your plant or at the Pfaudler laboratory.

Glassed Steel Long Used For Tough Corrosive Problems

Field data which form the basis for Pfaudler's new guarantee against corrosion has been compiled from thousands of installations, such as these glassed steel reactors in use at Distillation Products Industries. Pfaudler glassed steel units have solved problems of corrosion since 1884, are continually being improved to meet new demands of higher temperatures and pressures.

Three reasons why you can now get this unusual anti-corrosion guarantee

Like all Pfaudler chemical processing equipment, glassed steel *always* has been guaranteed from the standpoint of workmanship.

But why is it that you can now get a *corrosion* guarantee—a written agreement that your equipment will hold up under corrosive attack for at least a year?

Reason No. 1 is the glass itself. Pfaudler's new acid-alkali-resistant glass, now standard on chemical processing equipment, is a special type of glass which not only resists most acids, but also can be used for alkalies up to pH 12 and 212° F.

Reason No. 2 is the sensible approach to a specific problem by corrosioneers. We know what glassed steel can do, *and* what it can't. Field and laboratory data provide the background for deciding between glassed steel and other materials.

Reason No. 3 is our general policy on the equipment we sell. During its fabrication, we inspect it carefully at several check points. No vessel for severe chemical service leaves the factory until every square inch inside has been given a spark test to make sure the glass completely covers the steel to a certain minimum thickness.

12-MONTH GUARANTEE against corrosion is now offered with Pfaudler glassed steel equipment for processing a number of specific chemicals; hydrochloric acid, discussed in this article, is one of them. Other products which are covered under this unique guarantee will be discussed in future issues of *Corrosioneering News.* Watch for them.

NO LEAKAGE
NO CONTAMINATION
NO STUFFING BOX

Lapp PULSAFEEDER
CONTROLLED-VOLUME CHEMICAL PUMP

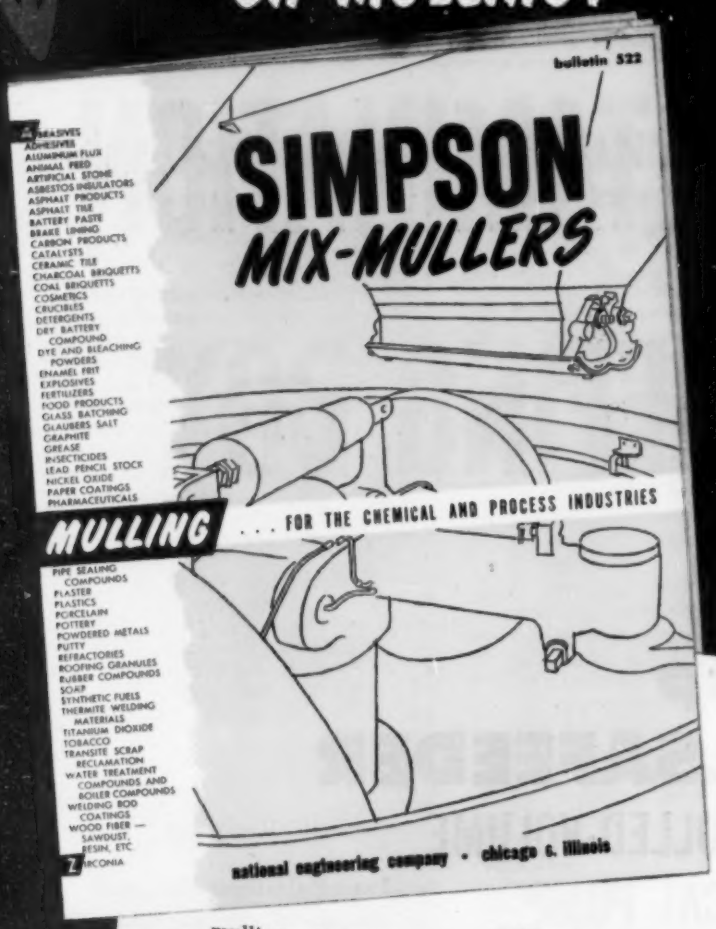
Lapp Pulsafeeder is a combination piston-diaphragm pump for controlled-volume pumping of fluids. Reciprocating piston action provides positive displacement. But the piston pumps only a hydraulic medium, working against a diaphragm. A floating, balanced partition, the diaphragm isolates chemical being pumped from the working pump parts—eliminates need for stuffing box or running seal. Pumping speed is constant; variable flow results from variation in piston-stroke length—controlled manually by hand-wheel, or, in Auto-Pneumatic models, by instrument air pressure responding to any instrument-measurable processing variable.

WRITE FOR BULLETIN 440 *with typical applications, flow charts, description and specifications of models of various capacities and constructions. Inquiry Data Sheet included from which we can make specific engineering recommendation for your processing requirement. Write Lapp Insulator Co., Inc., Process Equipment Div., 500 Wilson St., Le Roy, N.Y.*

Lapp

If you're mixing one of these products
. . . or any wetted or pasty solid material

HERE'S YOUR HANDBOOK ON MULLING!



There's nothing *new* about mulling — it dates back to the tethered ox and stone wheel. What *is* new is industry's increasing need for the kind of blending that can be realized *only* with mulling.

Here's your chance to find out more about how mulling can fit into your picture. See why and *where* it differs from ordinary mixing methods . . . how, through uniform blending, you can make the most of today's all too valuable ingredients — yet prepare a mix *faster* and more economically.

Sure, we talk about Simpson Mix-Mullers, but so will *you* — after you've read the specs on the new F Series because if you want to bring your catalog file up-to-date on the *latest* in mulling. Send for the handbook today. There's no obligation, but please use your letterhead.

FOR YOUR CONVENIENCE in determining capacity requirements a table is included in the bulletin for converting the measurements of various substances to cubic feet.

SIMPSON *MIX-MULLER*® DIVISION
NATIONAL ENGINEERING CO. (Not Inc.)
628 Machinery Hall Building
Chicago 6, Illinois

LETTERS TO THE EDITOR

(*Continued from page 6*)

in discharging their responsibility to their country as well as to their companies, must increasingly give attention to these national security factors.

Washington, D. C. VICTOR C. SEARLE

More on Operations Research

I am afraid that neither the practitioners of Quality Control or Operations Research will like your statement on page 27 of the January issue that "sometimes this technique is called operations research." Statistics is only one of many scientific tools that may be used by Operations Research in applying the scientific method to the solution of problems of operating management. Both disciplines make use of statistics, but this does not make them equivalent.

Cleveland, Ohio GEORGE D. CREELMAN

More Chemical Engineers as Presidents of Universities

You will recall that . . . I mentioned that I was glad to see the note on page 72 of the March issue of C.E.P. about Cliff Furnas. But I mentioned that Cliff was not the only chemical engineer heading a university.

F. H. Hovde has been president of Purdue since the War. Hovde received his B.S. in Chemical Engineering from the University of Minnesota.

C. W. Borgman was elected president of the University of Vermont several years ago. Borgman is an active member of the Institute. I think that I am correct that he was active in the work of the student chapter committee some years ago.

These are two persons heading universities who have Chemical Engineering degrees. Possibly there are a few others and you will, no doubt, hear about it now.

Chicago, Ill. J. H. RUSHTON

Note in C.E.P. re: Furnas elevated to chancellorship of University of Buffalo. He is not the first. Is not Fred Hovde, President of Purdue, a chemical engineer? I know that Carl Borgman at Vermont is a Chem. E.

R. F. HECKMAN

Rapid City, South Dakota

∫ Any more?

[Editor]

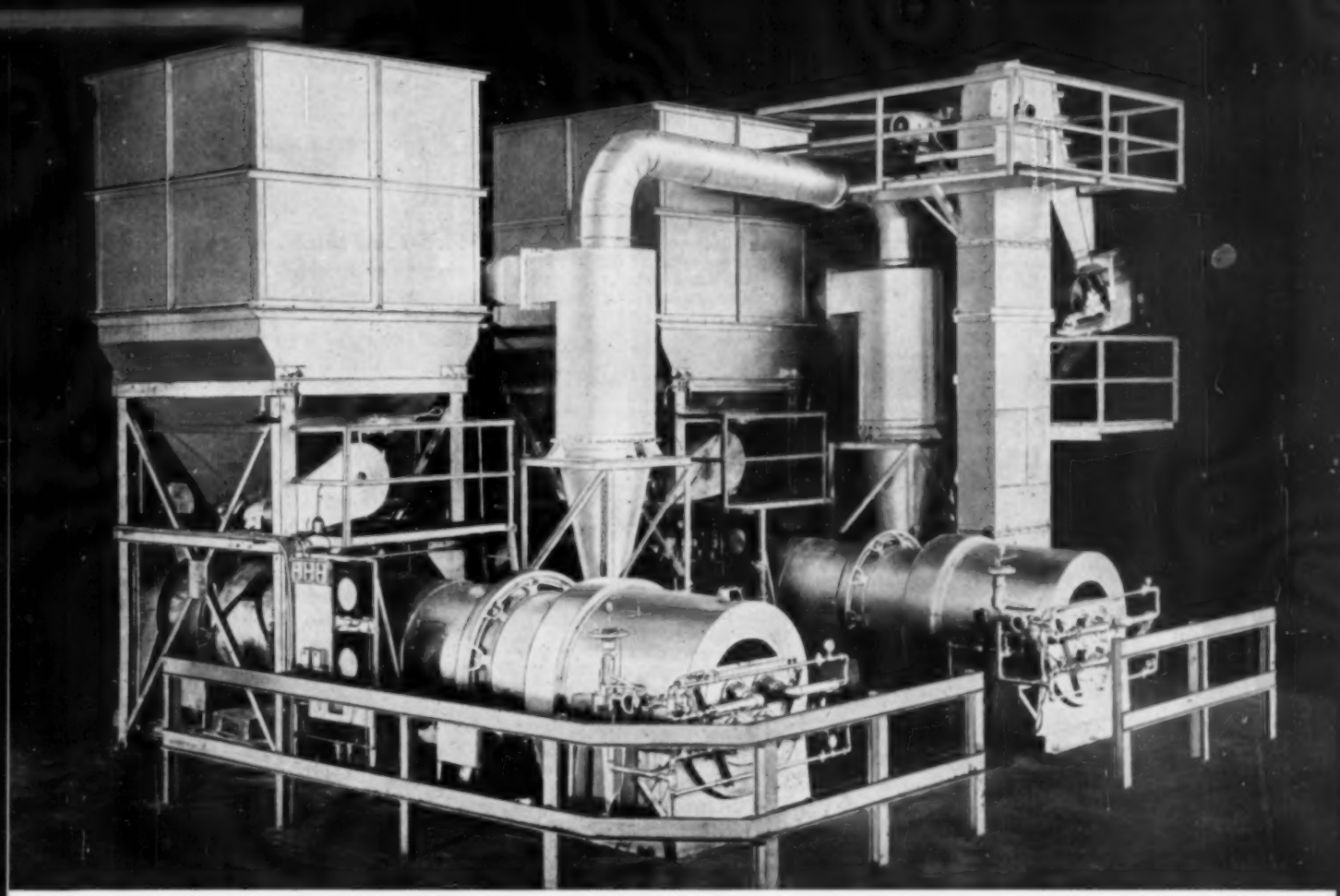
Thanks for the Bouquet!

Just a wee note to congratulate you on the fine appearance of the February issue of *Chemical Engineering Progress.* It is an interesting issue—one deserving of special mention.

I wish you success in maintaining the present standard.

New York, New York

ARCHIE J. WEITH



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NOTED AND QUOTED

More Than Sunshine in Florida

Some day Florida may be one of the great sources of nuclear fuels. It is estimated that in each ton of phosphate ore mined, there is an average of something less than a quarter of a pound of uranium which, at the present time, is only partially recovered. If all of the uranium in the phosphate ores mined in the State could be recovered, it is estimated that, at the present rate of production, it would result in approximately a thousand tons of uranium per year. It is also estimated that, assuming the complete utilization of, the uranium, only 90 tons of uranium would be needed to produce all of the electricity that was generated in the United States last year.

Joseph Weil
"Atomic Energy—Its Role in Florida's Future"

A. P. Is the Real Worry

Up until a few years ago the managers of companies had a pretty easy task selecting plant sites. They merely looked for the four M's. A site near plenty of *manpower*, with plenty of *machinery*, close to supplies of *materials*, and close to the *market*.

Now management has to worry about a couple of other letters spelling out Air Pollution.

J. H. Smith
before American Iron and Steel Institute meeting

Common Sense—A Necessary Adjunct to Technical Knowledge

He should have common sense. Karl Compton's sister, who you may know was married to the head of a missionary institution in India, once had an electrician who was wiring the house. She tried to explain to him something that she wanted, and when he did not understand, she said, "Oh, you know what I mean, just use your common sense," to which the artisan replied, "Madam, common sense is a gift of God; I have only a technical training."

W. L. Everitt, Dean of Engineering, University of Illinois. Address before Joint Dinner of Liberal Arts and Engineering Divisions, Association of Land-Grant Colleges and Universities.

In his talk titled, "And Who Knows Whether You Have Not Come to the Kingdom for Such a Time as This?" Dr. Everitt discussed *New Frontiers* and considered some of the characteristics of the frontiersman. The one quoted above is one of them.

[EDITOR]

New-Fashioned Power

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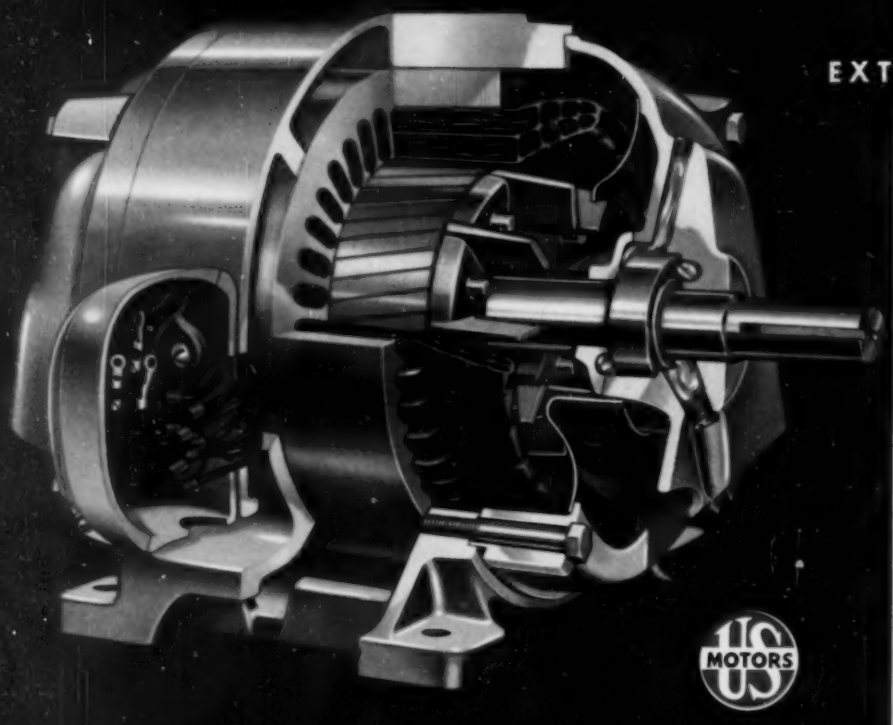
The fully-protected motor—improved all the way through



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  Protects against moisture and abrasives
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  Electronically-balanced for smooth running
- ✓ **LUBRIFLUSH TRANSVERSE LUBRICATION**
  Gives longest bearing life
- ✓ **SPLIT DOME, CAST-IRON CONDUIT BOX**
  Easier to make connections
- ✓ **NORMALIZED CASTINGS**
  Prevent warping and misalignment
- ✓ **STAINLESS STEEL DATA PLATE**
  Non-corrosive; permanent clarity
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U. S. MOTORS is proud to offer an advanced development of the Uniclosed concept--the new Type H motor. It incorporates all of the experience and unsurpassed performance achieved by years of building the famous U. S. Uniclosed motor, supplemented by new materials, new methods and improved design. Type H embodies a host of new, exclusive features, all directed to the objective of longer motor life and more efficient power. We have prepared a full-colored descriptive booklet presenting details of this completely new motor, packed with facts that will grip your interest. May we send a copy to you? Simply mail the coupon.

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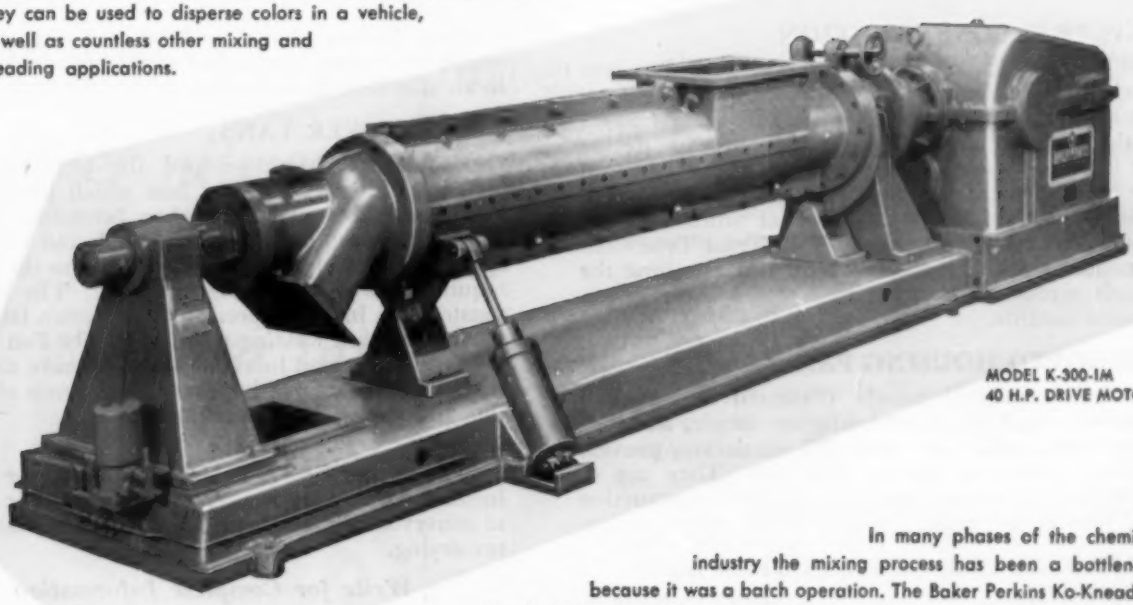
Two more BAKER PERKINS continuous-mixing KO-KNEADERS

(LIST SYSTEM)

now on the job

MODEL K-400-1M
30 H.P. DRIVE MOTOR

A switch from the batch process to continuous is now possible in many mixing, blending, and kneading operations, by use of these new Baker Perkins Ko-Kneaders. The two models shown here are both for Kneading heavy masses . . . chemicals, margarine, soaps, rubber, and plastics such as polystyrene, PVC, polyethylene, or acetate. They can be used to disperse colors in a vehicle, as well as countless other mixing and kneading applications.



MODEL K-300-1M
40 H.P. DRIVE MOTOR

In many phases of the chemical industry the mixing process has been a bottleneck because it was a batch operation. The Baker Perkins Ko-Kneaders break this bottleneck by converting to continuous mixing. When installed with the proper feeding and output handling equipment, these Ko-Kneaders make mixing largely automatic, and result in a better quality product along with savings in production costs.

BAKER PERKINS INC.

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NEW "P-4" CONSTRUCTION

"P-4" Construction means a precision-built, prefabricated, truss-type structure, providing a new measure of strength, rigidity and durability. Advantages to the customer are obvious: Longer service life for the Dryer; smoother operation; freer access for cleaning and maintenance; and reduction of installation time in the customer's plant of as much as 50%. Another important feature of "P-4" Truss Type Construction is that the special method of attaching the panels meets all Underwriter's Codes covering explosion hazards.

IMPROVED HOUSING PANELS

The new insulated panels (Patented and Patents Pending) used for the housing are larger, stronger, more rigid, and, with their "4" insulation, provide greater protection against heat loss. They are of trussed-and-tensioned, non-through-metal construction and incorporate expansion-contraction compensation.

IMPROVED AIR DISTRIBUTION AND CONTROL

The exceptionally high drying speed of "NATIONAL" Dryers results from a combination of adjustable fan power and a unique air distribution system, controlled to assure equal volume of air to the entire run. There is no "shading"—no uneven drying. This arrangement permits drying at consistently higher speeds than those previously permissible. Patented Indexing Orifices, Turning Vanes and other devices and arrangements assure unequalled versatility and precision in air distribution and control.

SUPER-POWER FANS

"NATIONAL" has developed the adjustable-pitch principle into its axial-flow fans which provides far greater operating potentials than heretofore used in any drying machinery. Greater speeds and volume of air can now be employed and adjusted to the specific requirements of the drying operation. The new fan construction includes special alloyed metals fabricated by an improved welding technique. The Fan mountings, insulation and lubricating systems have also been redesigned to provide improved smoothness of operation and virtually no maintenance.

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Other features of "NATIONAL" Conveyor Dryers include continuous hopper feeds; automatic leveler to conveyor belt; pressure extraction and heating for pre-drying.

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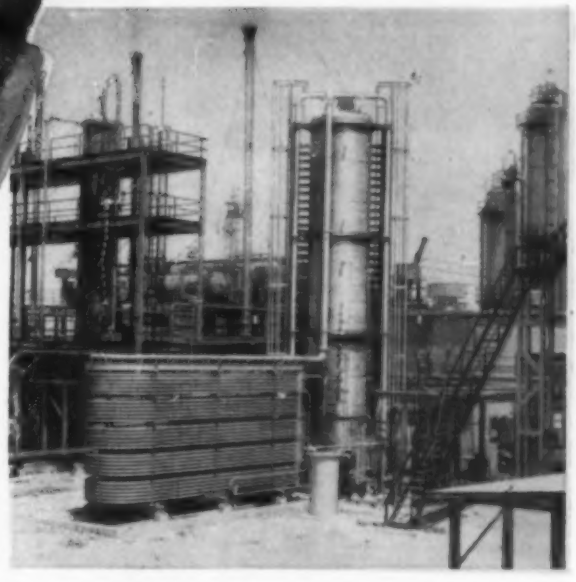
Mississippi Chemical Corporation's new nitric acid plant at Yazoo City, Mississippi, produces over 120 tons per day from a single-train unit.



"...now you can have greater nitric acid production with lower initial investment"

This new plant, incorporating C & I's new design, costs far less and is more compact than any nitric acid plant of similar capacity in the world. The plant has one absorption column, one converter and a centrifugal compressor with expander turbine. Its rated capacity is 120 TONS PER DAY; however, it is producing in excess of this figure without noticeable decrease in efficiency. The plant recovers more than one half of its necessary operating energy by utilizing tail-gas energy, thus greatly reducing operating costs.

If you are considering nitric acid production or expanding your present facilities, it will pay you to consult C & I. For only C & I can supply single-train plants capable of producing nitric acid at 120, 180, 200 and 250 tons per day.

C & I also designs and builds Complex Fertilizer Plants, Ammonium Nitrate Solutions and Solids Plants (Stengel Process), and Ammonium Nitrate Ammonia Solutions Plants.

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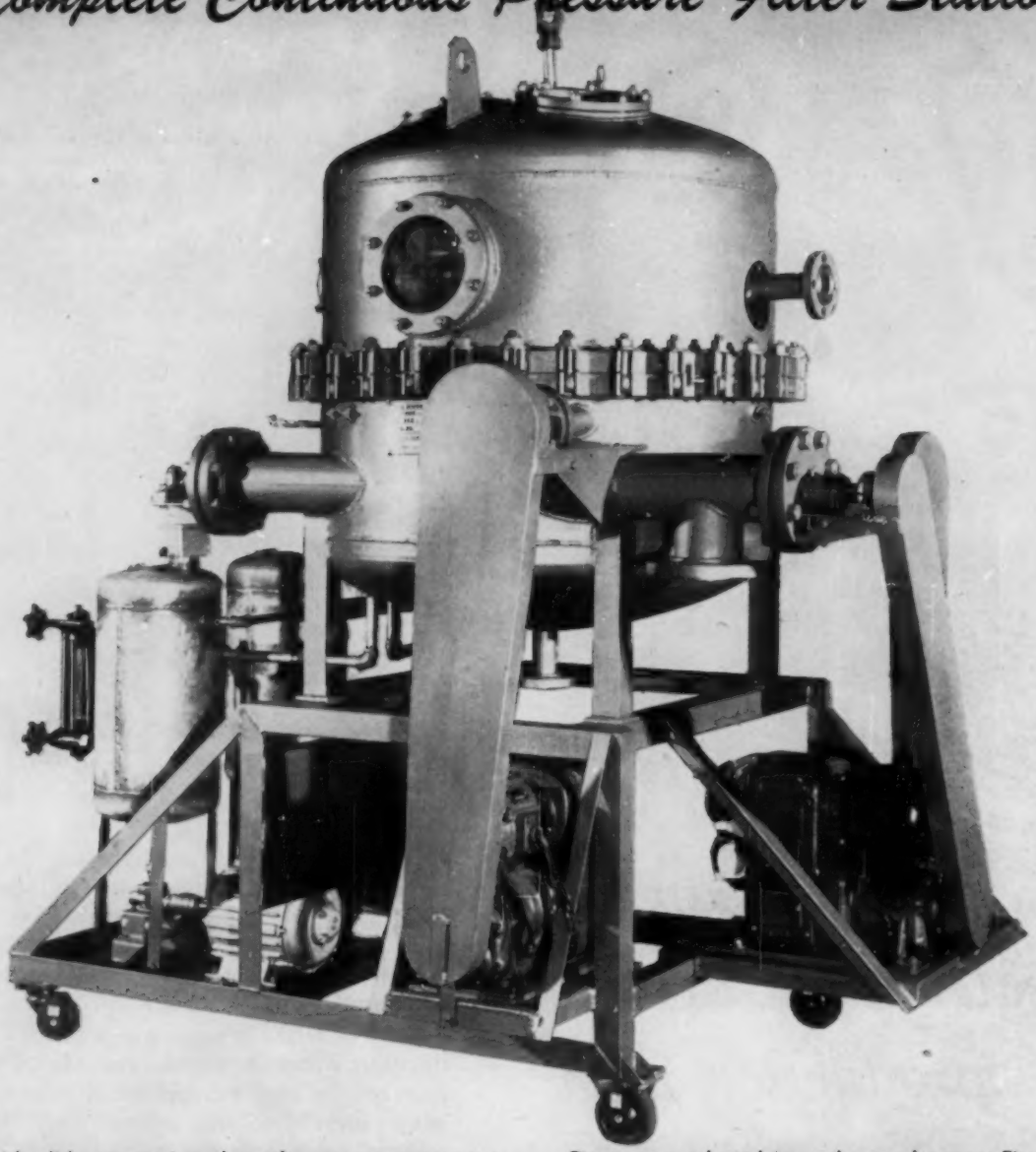

Liquid-solids separation through a pressure-vacuum differential has many applications in chemical processing.

Eimco designed, tested and approved pressure vessels of this type have found wide acceptance in many different kinds of jobs. Some of these use heat and others use inert gas. Some of the jobs involved combustible materials and others non-combustibles.

All of the installations are classified as far as Eimco is concerned to protect the customer's process or his idea and his flow sheet.

Eimco was selected in each case because Eimco's experience in the field of filtration is unsurpassed and Eimco's ability to engineer into each filter that extra quality that provides for greater product recovery and greater profits for the user.

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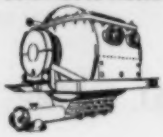
CONTINUOUS PRESSURE



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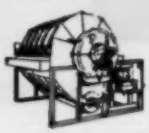

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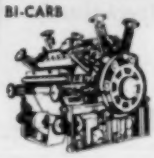


PRESSURE PRECOAT

PAN

MARGINAL NOTES

Pump Selection—The first volume of a new series of Technical Handbooks on Unit Operations for Types of Equipment. Compiled by C. F. Beaton and G. T. Meiklejohn; edited by J. E. Cran; published by Process Development Division, Research & Development Department, The Distillers Company, Ltd., Epson Surrey, England.

Reviewed by William R. Campbell, Jr., Service Engineer, Engineering Dept., E. I. duPont deNemours & Co., Wilmington, Delaware.

The authors have recognized the need for assembling information pertinent to pump selection. In their words:

No attempt is made to present a theory of pump operation or to deal with pump design; design is a matter for the specialists and is outside the scope of general chemical engineering. The information given here is intended mainly for process design and cost estimating purposes; that is to say, it is concerned with the selection of the most suitable type of pump for a given job, with the normal standards of performance and limitations of pumps, and with the numerous factors influencing the behavior of the various types.

To accomplish this, material has been drawn from many authoritative sources and presented in the form of tables, formulas, and graphs, the descriptions of which have been kept simple and at times appear elementary. However, this book will serve as a quick review for the process engineer having only infrequent contact with pump selection and will serve as an introduction to the engineer familiarizing himself with pumps. The volume will be useful also to the operating engineer who is faced with process changes or with the problem of improving performance of existing pumps.

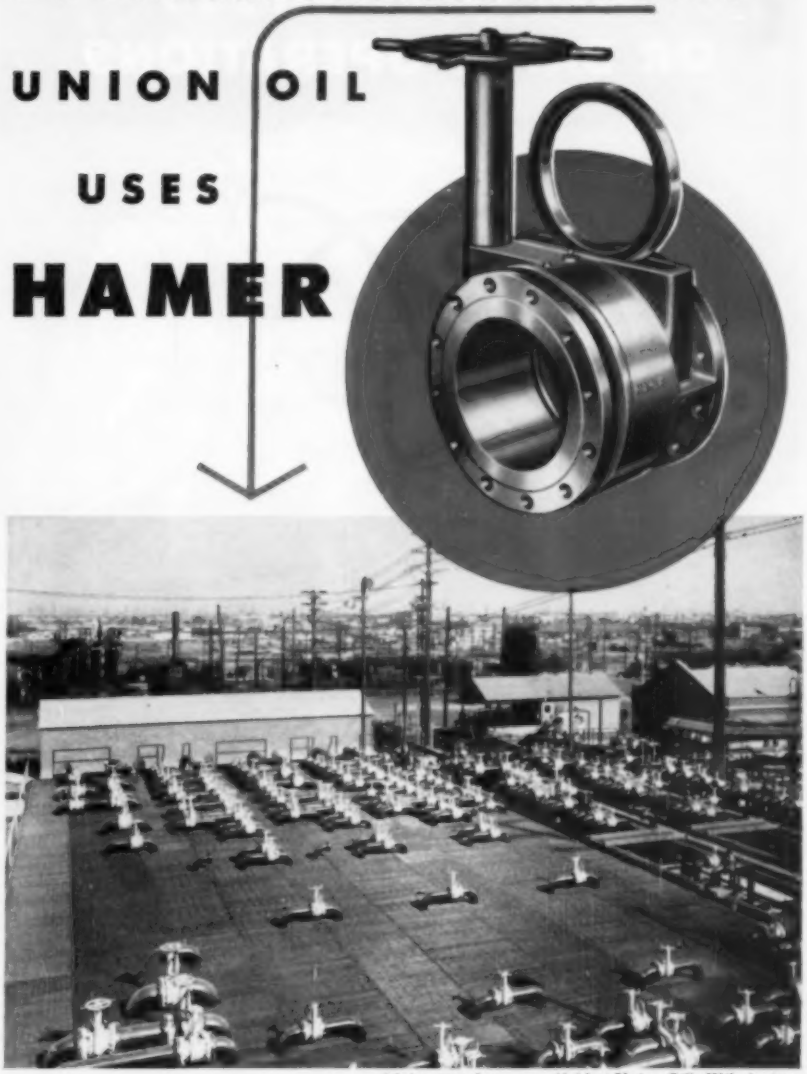
This information carries the engineer to the point where he has to settle such questions on pumps as: Which is the most reliable? Which has the best features for easy maintenance, and quick overhauls? Which manufacturer can give the best service in parts and delivery? The engineer must select the most economical pump, not necessarily the one with a low initial cost, but one which will be the most economical over the long haul.

Additional information could be added on vacuum pumps, mechanical seals, packing, and steam jets. Arrangements could be improved by including all data pertaining to one type of pump under one heading. The pres-

(*Continued on page 26*)

To combat contamination . . .

UNION OIL USES HAMER



Main pump house manifold at Union Oil's Wilmington refinery uses hundreds of Hamer Line Blind Valves.

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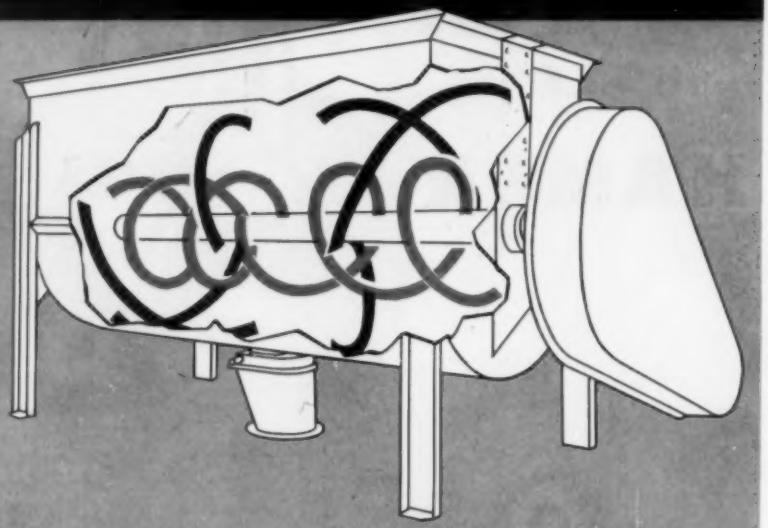

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Heavy-duty construction stands up under long runs and adverse processing conditions with a minimum of costly downtime.

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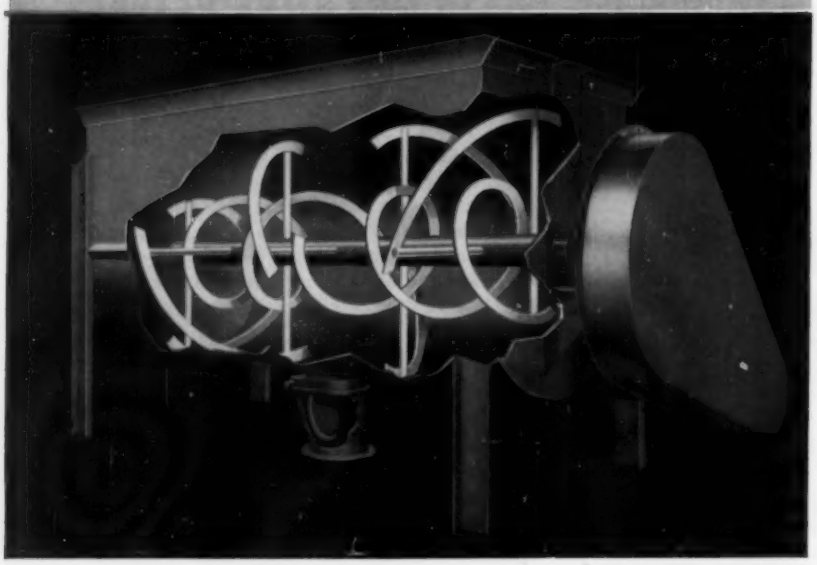


MARGINAL NOTES

(*Continued from page 25*)

ent arrangement requires an unnecessary thumbing of the pages. The ideas behind such a book are excellent. It is felt that with some reworking, the authors could have a very desirable handbook to offer to the public.

Adhesive Bonding of Metals. George Epstein. Reinhold Publishing Corp., New York, N. Y. (1954), 218 pages; $2.95.

Reviewed by J. O. Hendricks, Manager of Research (Tape Division), Minnesota Mining & Manufacturing Co., St. Paul, Minn.

The book is a handbook type which is of principal value to an aircraft engineer and to suppliers of adhesives for the aircraft field. However, persons interested in related fields such as automotive, electrical, and others will find the discussion of value. One would expect the author as a research engineer for North American Aviation, Inc., to emphasize his own field and that is what he has done. The scope covers not only metal-to-metal bonding but also a host of other materials which are bonded to metals. The adhesives which are treated in most detail are those of the thermosetting type, principally phenolic resin formulations and epoxy resins. Adhesives for use in airplane structures are treated in some detail with respect to composition, testing, and bonding.

As already indicated, the book is primarily written for the use of the engineer and is not a theoretical treatise. However, the adhesives, methods of bonding, and uses described are applicable to many other industries. Anyone interested in adhesives can well afford to read the manual.

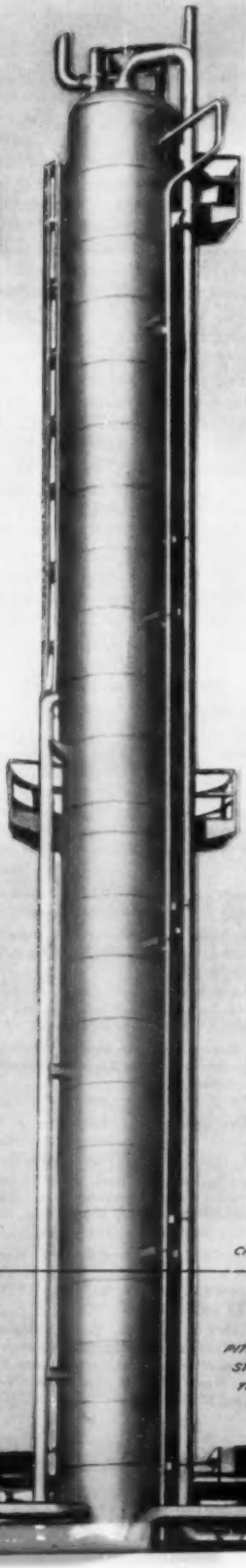
Two Ears of Corn (By Way of the Chemical Kettle). Claire Leavitt MacDowell. The Pequot Press, Stonington, Connecticut (1955), 242 pages, $5.00.

Though there were many facets to the life of Charles H. MacDowell, only one has professional interest for the chemical engineer, namely his accomplishments in the fertilizer industry—his efforts in the development of chemical plant foods, and in the scientific application of fertilizers to increase the country's supply of foods. This man MacDowell from central Illinois, at an early age took a job with Armour & Company, meat packer of Chicago, Ill., and subsequently began a study of that company's poorly utilized or wasted end

(*Continued on page 28*)

MARGINAL NOTES

IF YOU WANT **PROVED ABILITY...**



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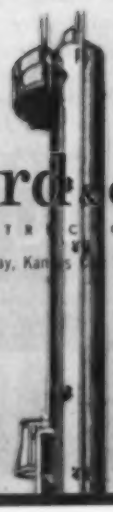

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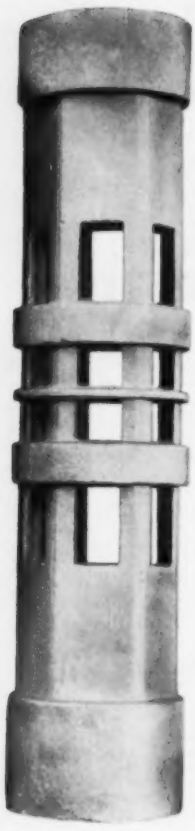

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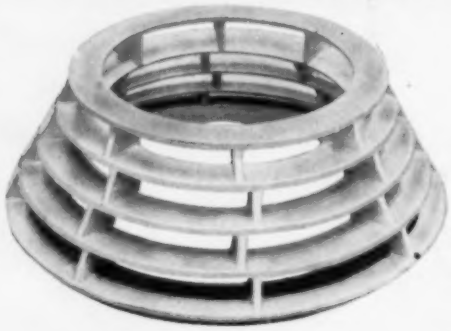

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MARGINAL NOTES

(Continued from page 26)

materials. The consequent survey, envisioning new methods, new materials, chemical manufacture, and the talents of engineers, resulted in the building up of one of the largest organizations of its kind in the country.

The many details accompanying this pioneering work are enumerated by Claire Leavitt MacDowell, his wife, in the story of her husband's activities, which began with his school days in Lewistown, Ill., and ended in his well-earned, yet busy, retirement in Florida. In between were crowded years —he was born in 1867 and retired in 1941—when MacDowell introduced revolutionary methods in by-product recoveries, in fertilizer and chemicals manufacture, in mining processes, and in other processes for the making of albumen, soaps, glycerine, etc.

From his diary, notes, and scrapbooks the author has culled some interesting sidelights on the man and his times. He played his part over a long span of time and his was no minuscule role. He deserves well of the author's inscription—from Dean Swift—"And he gave it for his opinion 'that whoever could make two ears of corn or two blades of grass to grow upon a plot of ground where only one grew before, would deserve better of mankind . . . than the whole race of politicians. . . .' "—H.R.G.

BOOKS RECEIVED

Fifty-five Colorful Years. The Story of Paint in America. Ernest T. Trigg. The Pequot Press, Stonington, Conn. (1954), II-xvi+307 pages, $5.00.

Seventeenth Semiannual Report of the Atomic Energy Commission. United States Government Printing Office (1955), III-XIII+138 pages.

Progress Report to the Congress (December 31, 1954). III-V+57 pages, 25 cents.

Personnel and Civil Service. A report to the Congress (February, 1955). ii-x+101 pages, 40 cents.

Paperwork Management, Part I In the United States Government—A report to the Congress (January, 1955). ii-vii+24 pages, 15 cents.

These three pamphlets by the Commission on Organization of the Executive Branch of the Government.

Chemistry of the Soil. Edited by F. E. Bear. Reinhold Publishing Corporation, New York, N. Y. (1955), iii-x+373 pages, $8.75.

Titanium in Iron and Steel. Third in new series of Alloys of Iron Monographs. George F. Comstock. John Wiley & Sons, Inc., New York, N. Y. (1955), vii-xii+294 pages, $6.00.

The Chemistry of Portland Cement. New second edition. R. H. Bogue. Reinhold Publishing Corporation, New York, N. Y. (1955), vii-xix +793 pages, $16.50.

The Theory of Cohesion. Vol. 2 of Metal Physics and Physical Metallurgy, Pergamon Science Series. M. A. Jaswon. Interscience Publishers Inc., New York, N. Y. (1954), v-viii+245 pages, $5.75.

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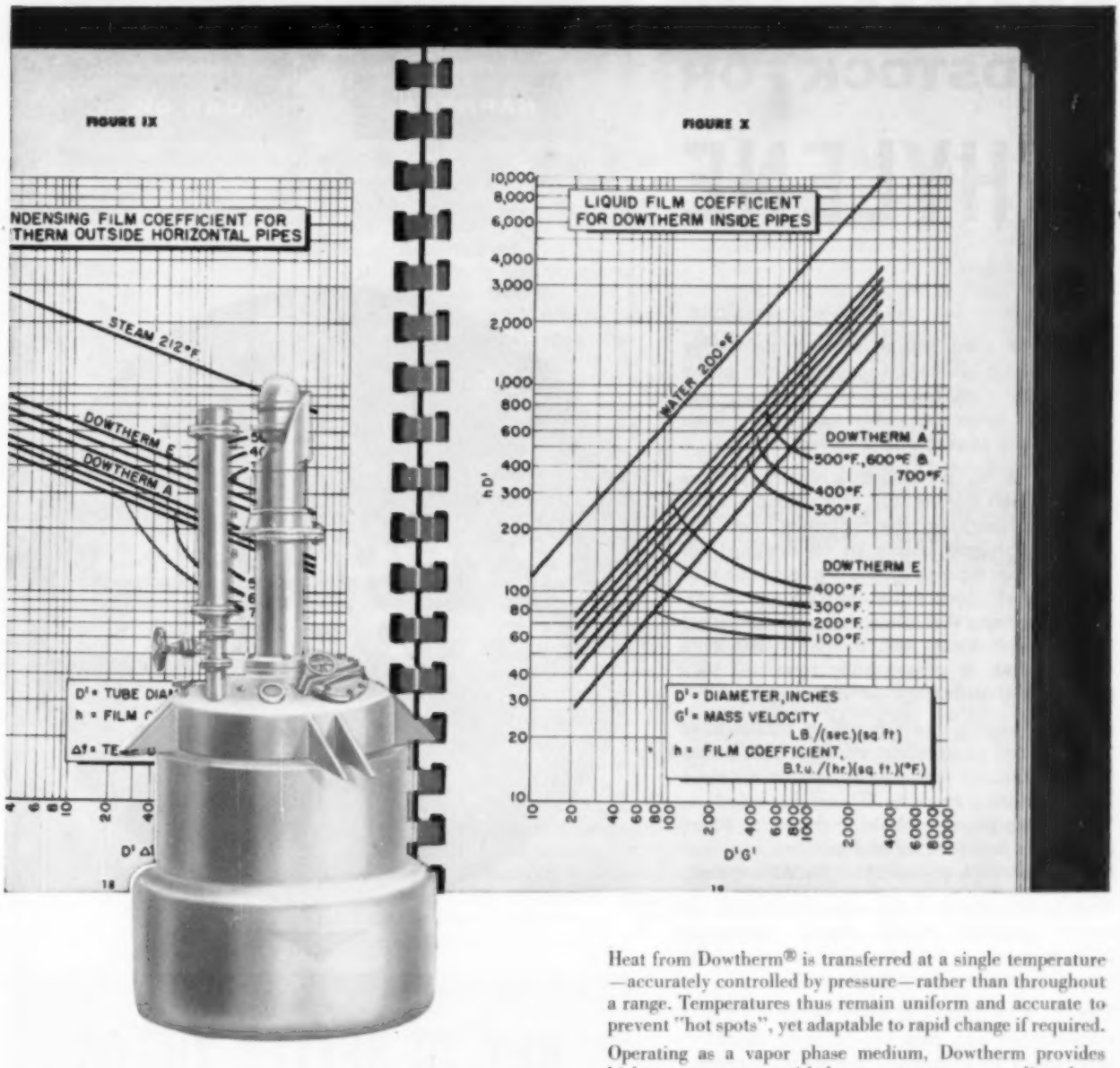

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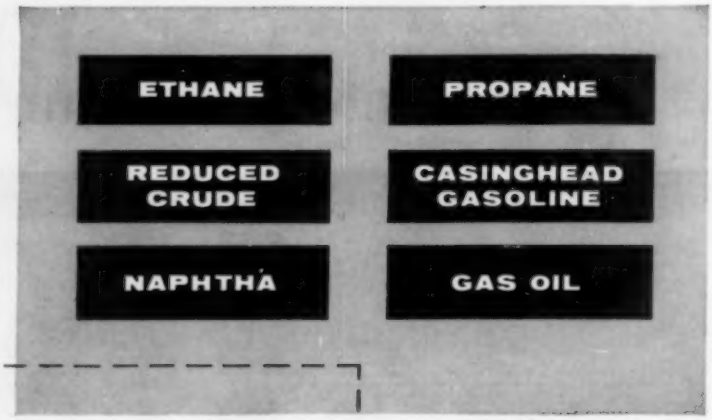

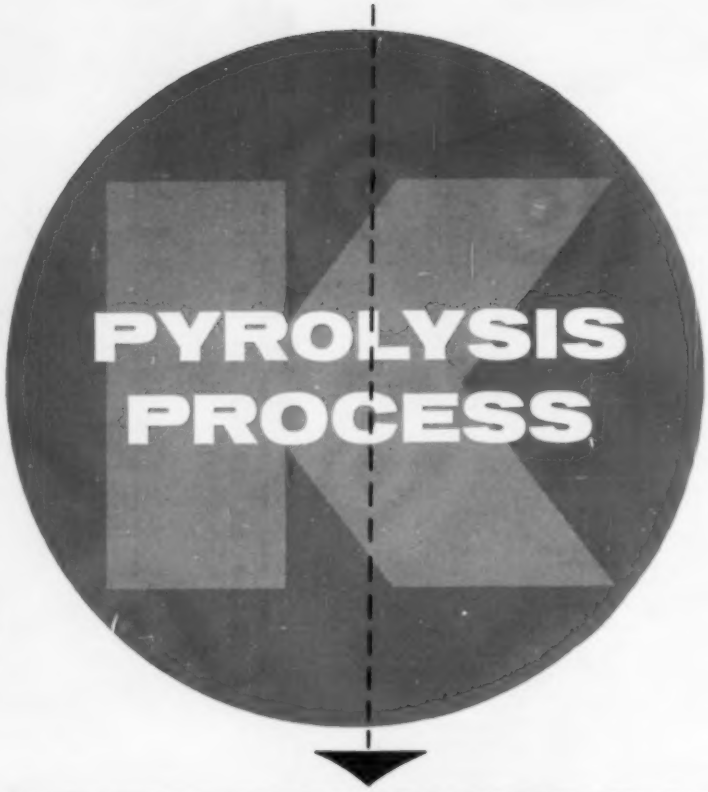

In ethylene manufacture, process engineering by The M. W. Kellogg Company offers many advantages over conventional systems, and guarantees optimum yields and purity from economically available feed stocks.

The key is M. W. Kellogg's steam-pyrolysis process. Used successfully in England for the cracking of heavy naphtha, it permits ethane and propane pyrolysis plants to be designed for higher yields; makes possible the economic production of ethylene and other olefins from casinghead or natural gasoline, residuals, and other low-value products; and indicates that even crude oil can be economically processed to a maximum of olefins instead of to gasoline.

M. W. Kellogg's steam-pyrolysis results have been marked by excellent yields of high purity olefins, generally higher than can be obtained by conventional cracking. This is due largely to the Kellogg process following cracking, where the stream is separated and purified in a low-temperature, low-pressure fractionation system.

Equally important, is the remarkable high on-stream efficiency which permits continuous plant operation at high conversions without the need for spare cracking furnaces.

The M. W. Kellogg Company has accumulated considerable cost data on ethylene manufacture, based on pilot plant and actual commercial production. Interested firms are invited to review these data with M. W. Kellogg chemical process engineers.

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SILICONES

John T. Goodwin, Jr.

Midwest Research Institute
Kansas City, Missouri

CEP trends

Gradual reduction in the price of silicones is leading to development of many new commercial uses for these synthetic chemicals which are derived basically from natural gas, sand, and salt, and which have been in production only since late in 1942.

In these 13 years a $30,000,000 industry has been built up through research into commercial possibilities inherent in the manufacture of silanes, combined with the study of the properties of their derivatives. Yet it can be readily believed that the surface of this industry has barely been scratched. What is now a sizable synthetic chemical business can take its place among the giants, as soon as the price-volume cycle is adjusted.

First, silicones sold for approximately $8.00 a pound and the present price is down to $3.00. Much study is being given presently to chances for further reduction, because it is generally agreed that the volume of silicone products used would be greatly increased if the price dropped to a level of around $1.00 a pound. Just when this new low-price level can be reached is problematical. It is estimated that it will require 10 years. However, there is always the possibility of some phenomenal development suddenly expanding production volume. What can be counted upon is a gradual decline in price from the present $3.00 toward the optimum $1.00 a pound.

Diversified Fields for Silicones

Today it is certain that practically every business enterprise is making some use of silicones. Big users are the blue ribbon companies of the country, such as Ford, General Electric, Westinghouse, Goodyear, Goodrich, Firestone, etc. The aviation industry is extremely silicone conscious, especially firms like Boeing and Lockheed. The chemical companies, of course, belong high up on the list–Dow, DuPont, and Union Carbide. Then the wax makers, S. C. Johnson, and Simoniz have found in silicones a way to improve their products.

Some of the newest uses are surprising. It is claimed currently that silicones have healing properties and they are introduced into ointments for chapped hands and for cosmetic purposes. The leather industry ascribes water-repellent properties to silicones, which now are helping to make better shoes.

Meanwhile, research on the subject continues to be active.

Some recent developments indicative of expanded silicone use include the high-temperature magnet wire enamels, the silicone pressure-sensitive adhesives now appearing in the market, and the leather treatment application. However, these are only three of the many new product developments which are in evidence at the present time.

Interest is being given to the mixture of silicones with organic resins and plastics in an attempt to improve the physical properties without losing the exceptional properties of the silicones. For example, silicone rubbers and resins do not have the strength and toughness of many organic materials, but they have the extreme thermal stability which makes them desirable. It is now believed possible that the silicones may be modified with organic materials to improve the over-all properties and to give a product which is better from physical standpoints, but still has good thermal properties and is lower priced.

The main commercial development of silicones in the immediate future will be due probably to the following: their use as plasticizers for organic materials, and as adhesives, both rigid and pressure sensitive; to enlarged electrical uses now that a satisfactory high-temperature magnet wire enamel has become available; in high quality paints and enamels; and to a general enlargement of the applications based on the present properties of the products.

Fundamental research was carried out for 5 years before a single sale of any silicone material was made. During these 5 years, the studies were concerned with methods of manufacturing the silanes, which are the silicone monomers, and with the study of the properties of the products derived from them. It was noticed early that the silicones had exceptional thermal stability and oxidation resistance. Other properties, which soon became of interest, were the surface activity and the small change in properties of the silicones accompanied with large temperature changes.

(*Continued on page 36A*)

Chempump

prevents costly leakage

at
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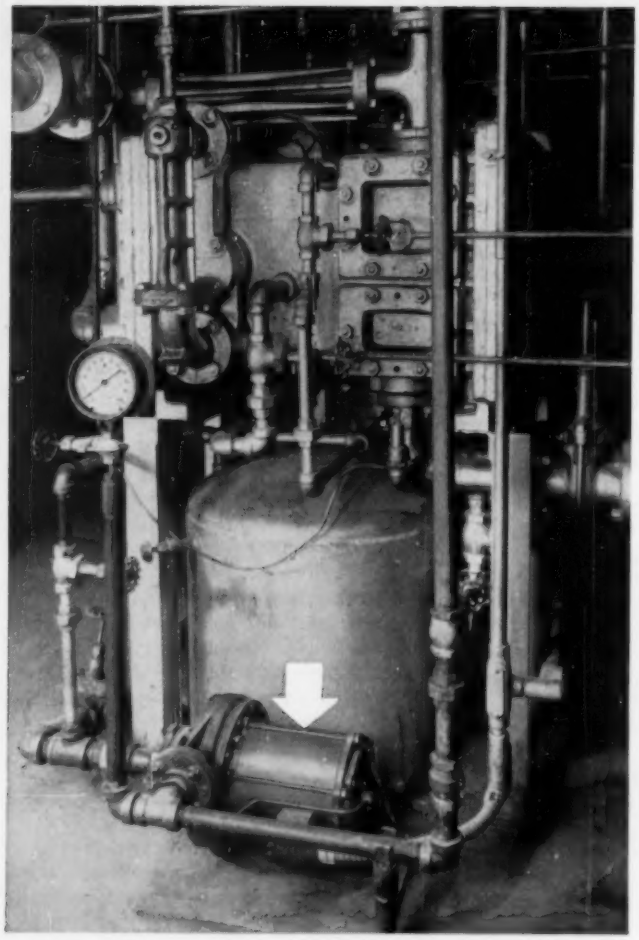

2 hp *Chempump* installed on condenser unit at Bound Brook, N. J., plant of Bakelite Company. This is a vacuum system operating at 28 inches of mercury. Pump discharges at 9 psig. Based on outstanding performance of *Chempump* under extreme vacuum, company is purchasing additional units.

PUMPING condensate from a condenser unit under vacuum posed a critical problem at Bakelite Company. If the pump lost its prime, the condensate would fill up the tank and back up into the system, causing considerable lost time and damage. Any air leakage would destroy the vacuum and render the system inoperative.

Previous pumping equipment required frequent maintenance due to stuffing box leakage. With installation of a seal-less *Chempump,* however, all leakage and vacuum problems were eliminated. Virtually maintenance-free, *Chempump* has shown outstanding performance.

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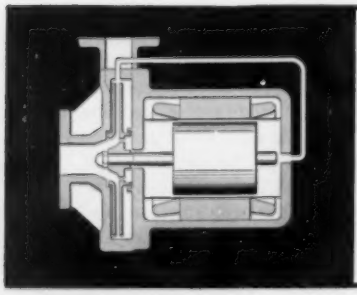

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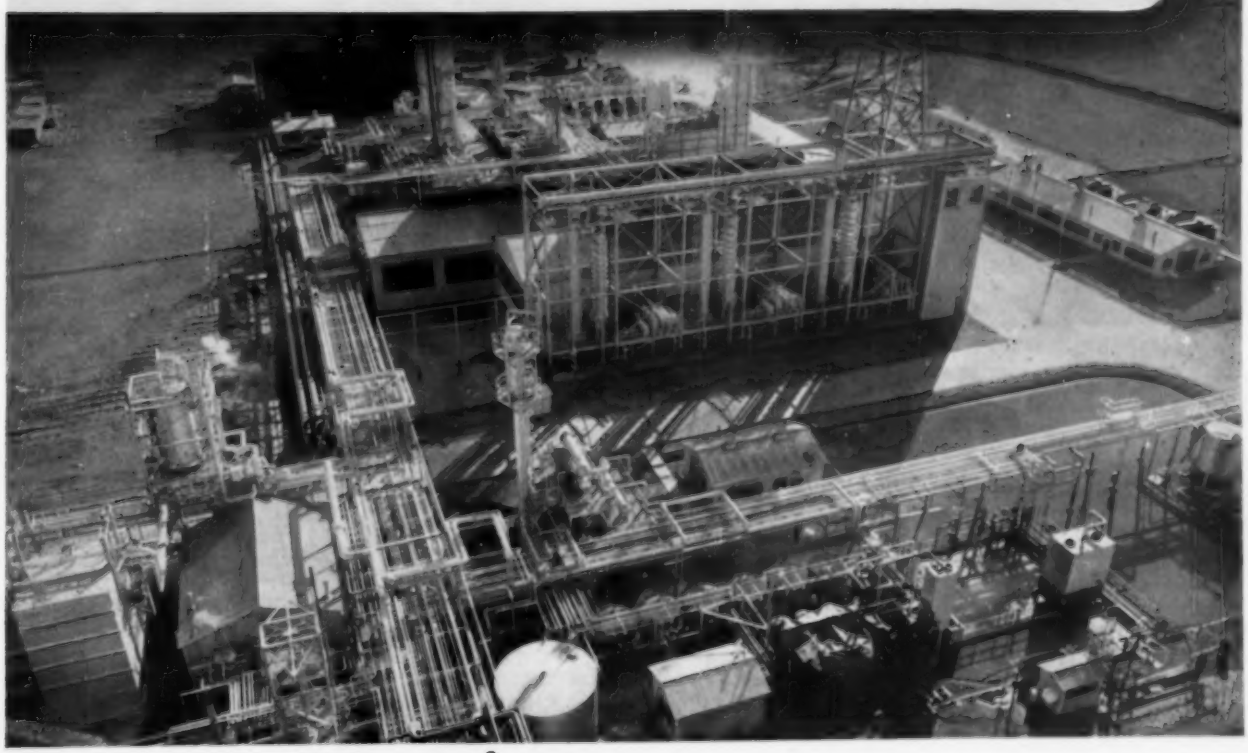

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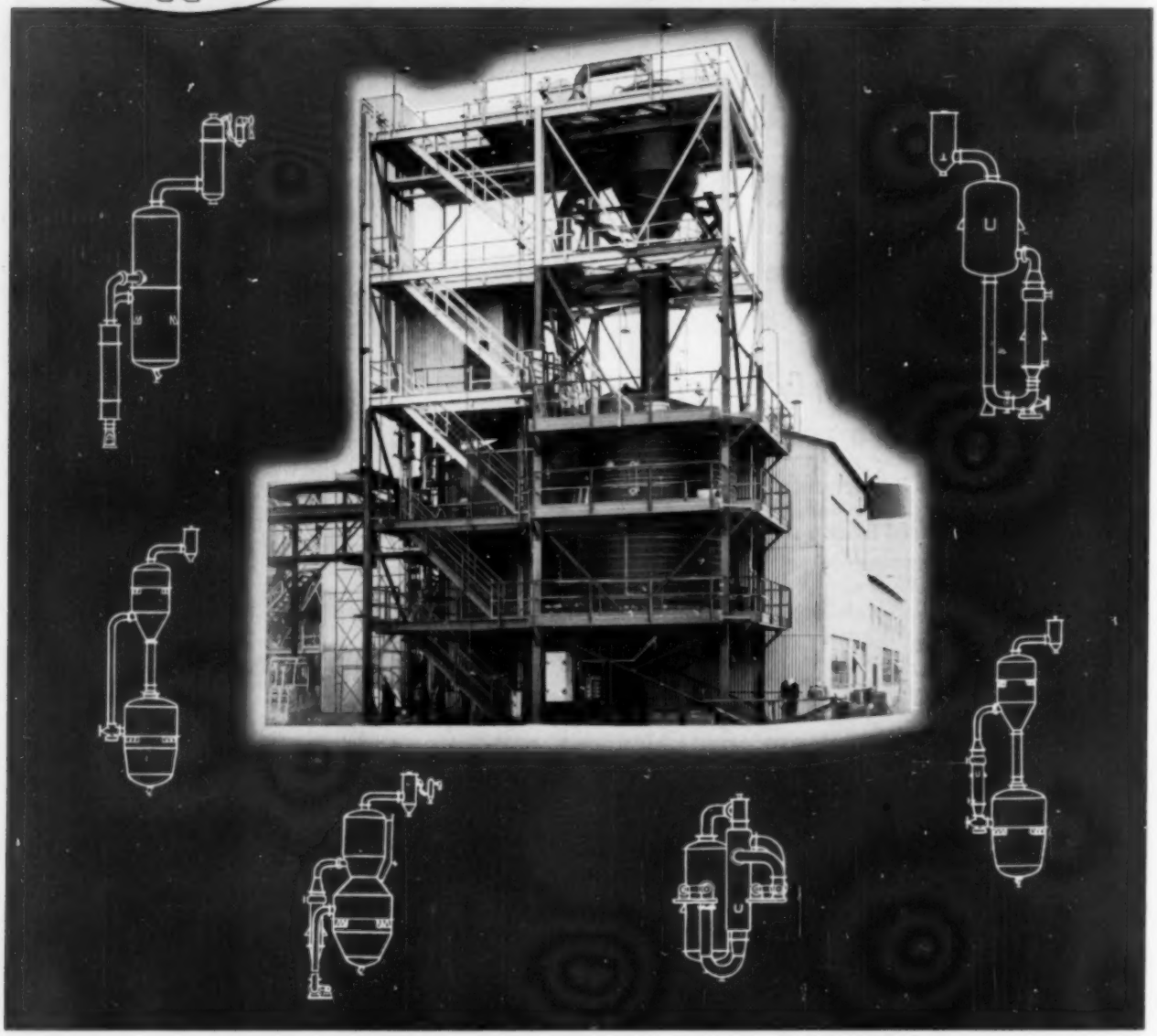

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CEP what's in this issue...

you may be interested in—

REMEMBER WHEN - (p. 205) you were a new B.S. in Ch.E.? We did when we wrote this month's Opinion and Comment - a word of advice.

IF YOU HAVE ANYTHING TO DO WITH CENTRIFUGAL PUMPS - (p. 207) specify, use, or even build them - chances are you'll find the Ullock article a gold mine. Coming from the vast experience of Carbide and Carbon, this should help you determine which pump features will serve you best for future process applications.

EXTRACTIVE RENDERING - (p. 223) Conventional methods of cooking followed by pressing may well be replaced by a new process which extracts the oil and other desired substances from wet tissues. Advantages: Better grade products plus a complete absence of offensive odor and water pollution.

DEPRECIATION - (p. 227) is behind a large portion of chemical manufacturing costs according to Dupont's Lawrence ... who further admonishes that because of rising investments due to automation, some real clear thinking is going to be necessary to solve the problem incurred. Bonus: Reader is also brought up to date on the 1954 tax law.

WHEN DISTILLING - (p. 232) we'll bet you haven't always properly considered what effect the length of liquid path is having on your plate efficiency. To get the benefit of Ethyl's experience read the article by M. F. Gautreaux and H. E. O'Connell.

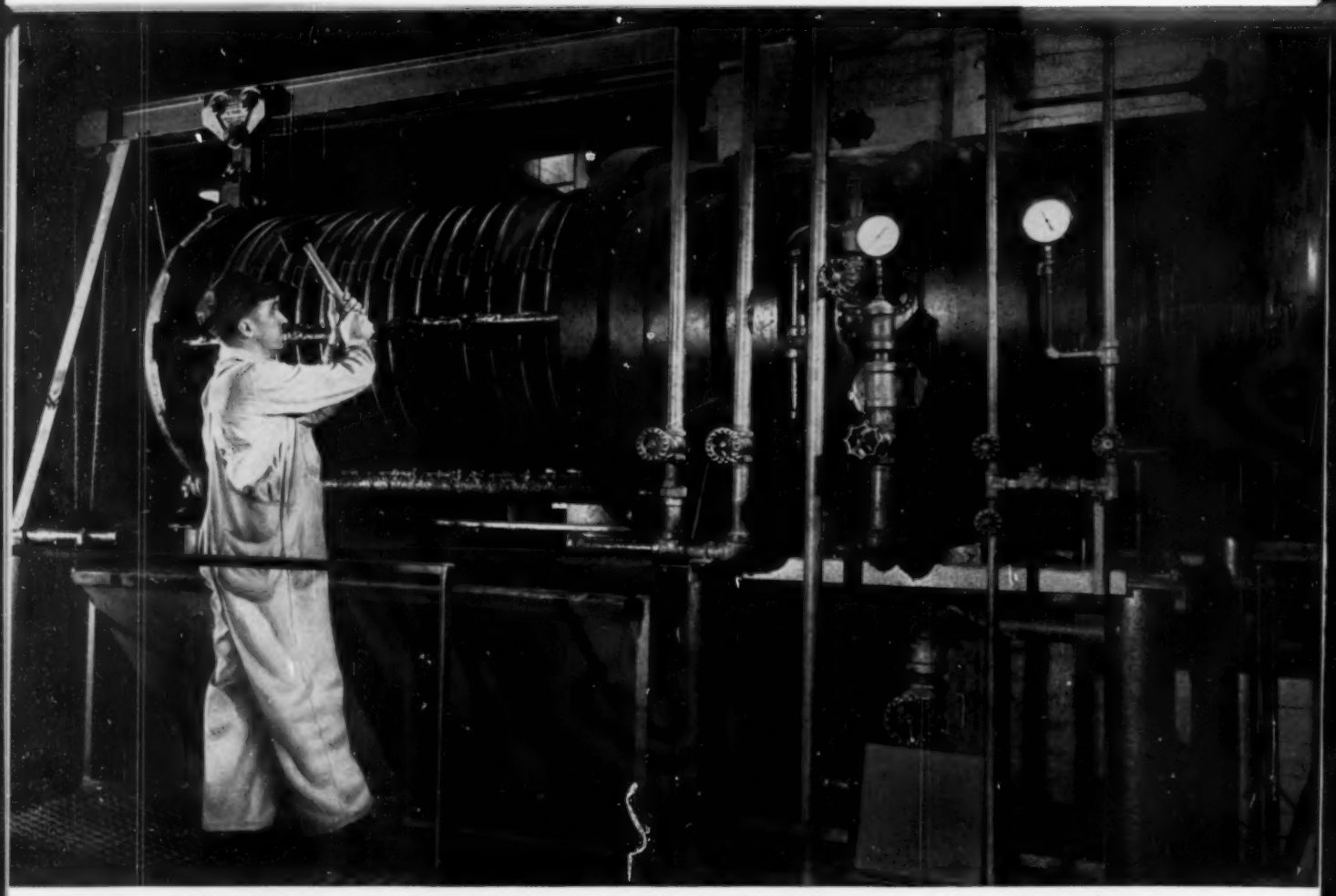
HOW DOW HAS HYDROCHLORINATED STYRENE - (p. 239) is revealed by author Montgomery. How effected: The reaction takes place in a packed column - but too slowly. Addition of suitable catalysts to packing surfaces, or as reactants to feed stream, speeds things up.

MULL THIS OVER - (p. 243) when rubbing action is needed along with mixing, the muller is usually the choice ... since one of the later-type mullers has recently undergone advances we feel many will appreciate this timely article.

USING SILICONES? - (p. 31). Now that their prices are coming down, chances are you will be interested in the leads given in this up-to-date article which covers the breadth of quite a sizeable family tree.

YOUR PUBLIC - (p. 48) is made up not only of those you try to influence but also of those to whom you look for increased recognition in your profession. Through this short article, Ray Dinsmore helps us all with a better understanding of a little-considered phase of professional development.

-- J. B. M.



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CEP

opinion and comment

The New Crop

Very soon the young chemical engineer will leave the campus to report for work on his first full-time job. How different his beginning will be from the experience of prewar generations! He has been sought by as many as twenty prospective employers, each using his most persuasive arguments to induce the young hopeful into his organization. Once the overtures of preemployment courtship are ended, however, and the new engineer has entered his group, the preliminaries will not have changed much from those of earlier years.

For a while it is impossible for the new employee to think of himself as other than *new,* as an individual being oriented to fill a particular place in an organization. How long this process takes varies. The sooner one begins to feel a part of the group, the better. Settling down to a place as one of the fellows on the team is imperative, and nothing—neither memories of inducements from other firms nor the harsh adjustment from college senior to minor employee—should deter one from entering into friendly give-and-take with his professional associates.

It is normal at this time for the young chemical engineer to muse over his other offers: should he have chosen otherwise? Yet until he has fully explored his own capabilities and the opportunities in his organization, he may make a great mistake by switching jobs. There is time for change.

While he is settling into his job, the young chemical engineer faces another problem—how to find at least a part of the intellectual atmosphere that he has recently left? In the larger firms professional activities are often programmed and made easily available; in the smaller companies one has to look outside but there is usually plenty of inducement from one's associates to join with them in many activities.

One of the most important aids to the new engineer is his local and national professional group. One of the major advantages to the young chemical engineer of membership in the A.I.Ch.E. lies in getting to know other chemical engineers and what they are doing.

C.E.P. welcomes the young chemical engineer as a member of the profession that expects much from him in the ever more technologically complex days ahead.

J.B.M.

Photo courtesy Eli Lilly & Co.

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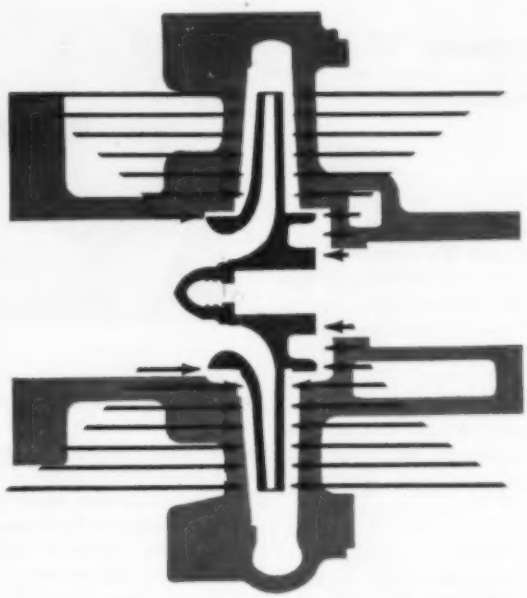
INTRODUCTION

Chemical Engineering Progress is privileged to present this paper—which is a method for evaluating the mechanical design of end-suction chemical process and refinery type centrifugal pumps. It has been written from the viewpoint of those who specify, purchase, operate, and maintain pumps. It is also intended to be helpful to pump manufacturers. Failures of individual pumps with attendant high maintenance costs studied at the plants of Carbide and Carbon Chemicals Company constitute the basis for the paper and have enabled setting levels of mechanical design consistent with reasonable maintenance costs.

In 1948 a standardization program was undertaken by Carbide working in cooperation with a number of pump manufacturers. This program included the establishment of master specifications and the preselection of available pumps for standard heads and capacities. A substantial reduction in paper work in the engineering and purchasing departments has resulted.



evaluating
THE MECHANICAL DESIGN OF END-SUCTION
centrifugal pumps

Donald S. Ullock

Carbide and Carbon Chemicals Company, South Charleston, West Virginia

Centrifugal pumps show symptoms of failure when trouble is experienced with their bearings, shafts, or shaft sleeves.

Such failures may be the result of (1) inadequate mechanical design, which reflects a weak shaft and/or bearings that are too weak for the loads imposed on them. Although poor hydraulic performance may be detected quickly, poor mechanical performance is not easy to detect. There has been (and still is) a widespread tendency to scale pump shafts solely on the basis of horsepower transmitted, which has been proved by these studies to be in error.

Lightness of bearing and shaft design has also resulted (and still does) because the purchaser so often demands the lowest priced pump meeting hydraulic specifications. It is hoped that one result of this paper may be to emphasize the value in pump procurement of quality factors. Recognition should always be given to the pump manufacturer who uses his skills in designing economical pumps so that efficient hydraulic performance is combined with good mechanical performance. This is accomplished by proper arrangements of the physical dimensions of the pumps.

If the pump is adequately designed, it should not fail or require undue maintenance because it operates at 3,500 rev./min. in contrast to those operating at 1,750 rev./min.

In addition to inadequate mechanical design, pumps fail (2) because of other factors such as improper application and installation, inappropriate operation, and maintenance procedures, and incorrect repair procedures.

A centrifugal pump should not be operated with its absolute suction pressure and total developed head below the values determined by the pump manufacturer. The installation, operation, and maintenance instructions provided by the pump manufacturer should be followed with care. In the repair of pumps, mechanics should be provided with essential information on clearance and dimensions. In some cases it is necessary to outline the steps to be taken in the proper assembly of the pump.

Factors in Pump Evaluation

The major steps in evaluating the mechanical design of centrifugal pumps are:

(1) Obtaining essential mechanical data from the pump manufacturer, including radial load constants and pressure measurements, or if possible, radial and axial load measurements.

(2) Making certain measurements on existing pumps, if necessary.

(3) Calculating any of the following not obtained from manufacturer, according to (1) above:
- **(a) Unbalanced radial loads**
- **(b) Pressures in the pump casing around the impeller**
- **(c) Axial loads on both sides of the impeller and the net axial load**
- **(d) Bearing loads**
- **(e) Bearing life**
- **(f) Shaft deflection**

(4) Considering and evaluating to a less detailed degree:
- **(a) Shaft rubbing speed**
- **(b) Pump rotative speed**
- **(c) Protection of the bearings**
- **(d) Stuffing-box design**
- **(e) Mechanical seals**

The evaluation is usually based on water and can be limited to only those pumps having the largest radial or combined radial and axial loads to be mounted on each of the manufacturer's bearing-bracket sizes. Specific gravity and viscosity are the only two important physical properties of liquids affecting the mechanical design of the pump. The shaft deflection will increase directly with specific gravity, and the bearing life will decrease with the cube of the specific gravity. An increase in viscosity is not likely to affect the pump-shaft diameter, but would only require

EVALUATING CENTRIFUGAL PUMPS

Continued

Author Ullock (a chemical engineer with a Ph.D. from Michigan) started his work on Carbide's pumps in 1946. During the past five years he has concentrated on the mechanical design of centrifugal pumps.

a larger size motor as the driver.

Through following the steps to be described, noting examples illustrating experiences with pumps, and referring to the Appendix when necessary, the reader may learn the technique of pump evaluation. From this, procurement may be guided, and existing pumps may be aided through design changes or through maintenance or operating procedures intended to favor the weak design.

Organization of Paper

1. Methods for calculating the unbalanced forces developed in the pump casing are presented. These forces include radial loads, pressures, and axial loads.
2. Methods are given for analyzing and evaluating the structure (bearing-bracket assembly) which supports the loads originating from the casing. Shaft and bearing design is evaluated by providing methods for calculation of bearing loads, bearing life, and shaft deflection. The critical speed for the shaft (due to the weight of the impeller) is discussed with values calculated for pumps of adequate mechanical design. Static and dynamic balancing of impellers is discussed. An analytical equation is presented for the calculation of shaft deflection (whip) caused by dynamic unbalance in an impeller.
3. Other evaluation factors are discussed: shaft-rubbing speed, pump speed, protection of bearings, stuffing-box design, and mechanical seals.
4. Assembly of pumps is summarized to point out some factors often overlooked in repairing pumps.
5. Calculated values are compared with measured values for five pumps of weak design. Two of these pumps were rebuilt and their performance is compared with the calculated values.
6. A sample calculation is presented in the Appendix to illustrate the calculations for the mechanical design of a pump.

Details of some of the material outlined above are presented in an Appendix. Appropriate references are given in various parts of the paper.

Information in the Literature

References in the literature admit to the matter of unbalanced radial and axial load in the pump casing, but consider radial load unpredictable. Some authors, however, point out its importance and the need to recognize it (*1, 4, 5, 9*).

Stephanoff (*9*) presents empirical equations, based on experimental data, for estimating the unbalanced radial loads. The methods described in this paper are limited to the so-called chemical-process and refinery-type horizontal centrifugal pumps with single-stage end-suction over-hung impeller. Multistage centrifugal as well as mixed-flow- and axial-flow-type pumps can be subjected to the same general analysis.

Unbalanced Forces Developed in Pump Casing

Two important forces develop around the impeller in the centrifugal pump casing. One force acts radially on the impeller periphery and causes the pump shaft to deflect; the other acts axially on the sides of the impeller and puts the pump shaft in compression or tension. The radial force is the resultant of the unbalanced pressures around the impeller and the unbalanced momentum of the liquid leaving the impeller. The axial force is due to the difference between the forces acting on each side of the impeller. These forces are caused by the pressures present and acting on the sides of the impeller. The direction of the net axial thrust depends on the design of the impeller and the pressure at the suction connection of the pump.

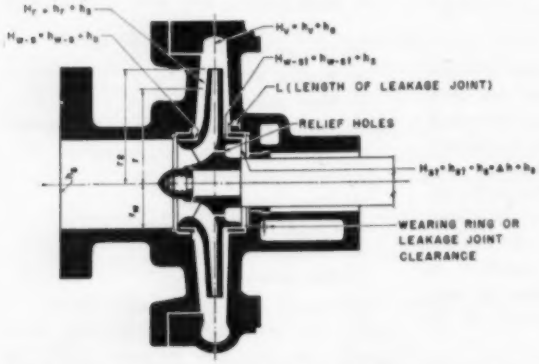


Fig. 4. Pressures in centrifugal-pump casing.

RADIAL LOADS

Unbalanced radial load is developed in a casing by the impeller. It is due to a variation in the pressure around the impeller and in the momentum of the liquid leaving the impeller. This radial load may be calculated from:

$$W_r = \frac{KhD_2B_2S}{2.31} \qquad (1)$$

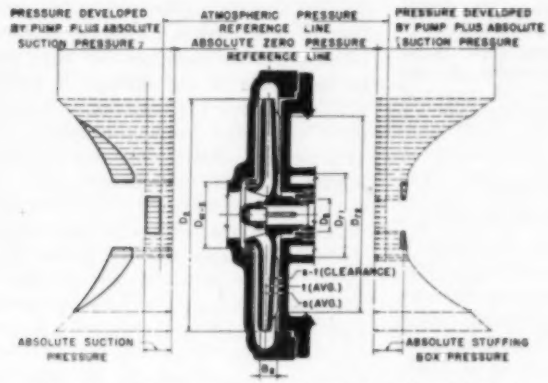
The value for the constant K depends on the pump's capacity, its speed, casing design, impeller diameter, cutwater diameter, and on some other factors which are not known. The value of the constant for pure radial load should be obtained from the pump manufacturer. When its value is not available, methods are presented in the Appendix for estimating the radial load constants under the subject "Equations for Radial Load Constants." *

* Equations (1A, B, C and D) and Figures 1-3.

APPENDIX AVAILABLE

Readers of this article who are interested in pursuing the subject of the mechanical design factors of centrifugal pumps to the full degree provided by the Ullock work, must have recourse to an Appendix. This is a separate publication containing detailed supplementary material referred to throughout the text of the accompanying article.

Copies are available from the Secretary, A.I.Ch.E., 25 West 45th Street, N. Y. 36, N. Y. Fifty cents should be enclosed with order to cover expense of handling and mailing. Carbide and Carbon Chemicals Company has prepared and made available this Appendix.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ABSOLUTE STUFFING BOX PRESSURE

Fig. 5A. Casing pressures and unbalanced axial load for closed impeller with suction wearing rings and back vanes.

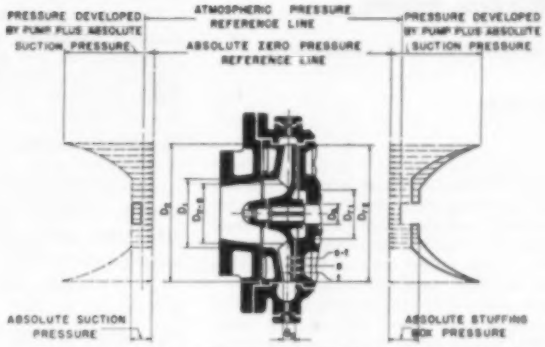
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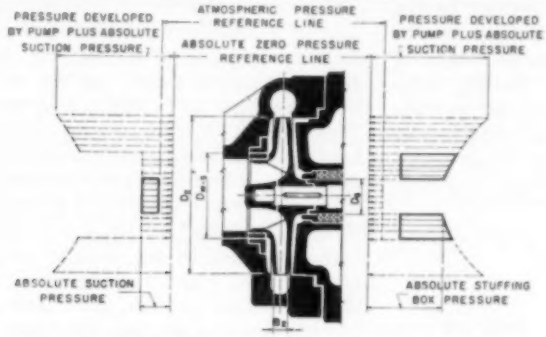
Fig. 5B. Casing pressures and unbalanced axial load for semiopen impeller with back vanes.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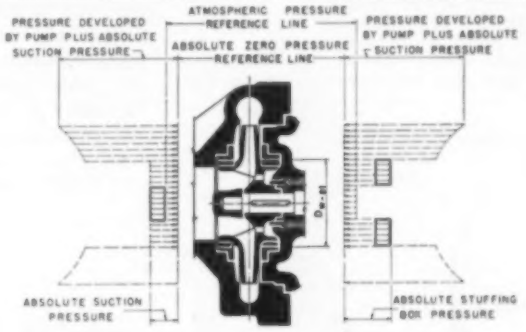
ABSOLUTE STUFFING BOX PRESSURE

Fig. 5C. Casing pressures and unbalanced axial load for closed impeller with suction wearing rings.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ABSOLUTE SUCTION PRESSURE
ABSOLUTE STUFFING BOX PRESSURE

Fig. 5D. Casing pressures and unbalanced axial load for closed impeller with suction and back wearing rings.

PRESSURES IN THE PUMP CASING

Axial loads are developed as the result of the pressures existing in the pump casing and their effect on the exposed areas of the impeller and the shaft. Though these pressures can be calculated, the values obtained are approximate. Preference should always be given to experimental measurements of pressure. Of most interest are the average volute pressure, the suction pressure, and the pressures at the wearing rings and the stuffing box. (All pressure terms used in this paper are expressed [as heads] in feet of fluid flowing. Lower case letters indicate head above suction head; capital letters indicate inclusion of the suction head.)

An additional thrust is developed at the eye of the impeller by the change in momentum of the flow as it makes a turn in the eye of the impeller. For the ordinary chemical process pump this increase in pressure is usually small in value and can be neglected.

Important pressure points in the pump casing are shown in Figure 4.* The highest pressure is at the discharge nozzle, and, since there is a velocity head change between the volute and the discharge nozzle, the volute pressure is the lower. The impeller rotates the liquid between it and the casing wall, causing the pressure at the wearing ring, h_w, to be less than the volute pressure, h_v. With relief holes in the impeller, leakage through the wearing-ring clearance allows a flow of liquid to the suction side of the impeller. The pressure h_{ss}, at the shaft or at the stuffing box will be lower than the pressure above the wearing ring and greater than the suction pressure. The addition of the suction pressure to these values gives the total pressure at the respective points.

* Figures 1-3 are included in the Appendix.

Effect of Impeller Design

Figure 5A illustrates graphically the magnitude of the pressures on both sides of the impeller. The length of the arrows represents the magnitude of the pressures in the pump casing. The effect of the back vanes is shown by the low pressures present on the stuffing-box side compared to those at the same radius on the suction side of the impeller. Areas bounded by the heavy lines indicate the pressures that are not balanced and the unbalanced axial load present.

Figure 5B shows a semiopen impeller with back vanes. At high speeds and with a large diameter, this impeller can develop a high unbalanced axial load.

Use of the back vanes offers the only effective means of reducing axial loads to a reasonable level. Care must be taken in the assembly of the pump because the clearances on both sides of the impeller are critical. The clearance on the suction side of the impeller affects the head developed by the pump. As the back-vane clearance is increased, the pressures over the back of the impeller increase, resulting in higher axial loads.

Back vanes should generally be avoided whenever possible, however, especially as a substitute for back-wearing rings. They are better than wearing rings for slurry service and are better when, in some materials of construction, they are used for highly corrosive and erosive services. Since the vanes constitute the only practical method to reduce the high pressures that would be present at the back of the impeller, they must be used on high-head single-stage, semiopen impellers. With lower pressures present, the unbalanced axial load is kept to a reasonable level.

The area bounded by heavy lines on the stuffing box side of the impeller is typical for operation at low capacity. At high capacity, if the back vanes are sufficiently large in diameter they can create a vacuum at the stuffing box. An unbalanced axial load will be present on the suction side of the impeller.

Continued

Figure 5C illustrates a closed impeller with the wearing ring on the suction side only. In this case the unbalanced axial load is toward the suction and can be large in value depending on the suction wearing ring and the impeller hub diameters.

Figure 5D illustrates a closed impeller with suction and back rings of the same diameters. Except for high suction pressures, the unbalanced axial load is controlled and is kept at a low value when the wearing rings are of the same diameters on both sides of the impeller and adequate relief holes are provided.

Methods for estimating the pressures in the pump casing are presented in the Appendix under the subject "Equations For Pressures Developed in Pump Casing."*

* Equations (2) to (12) incl.

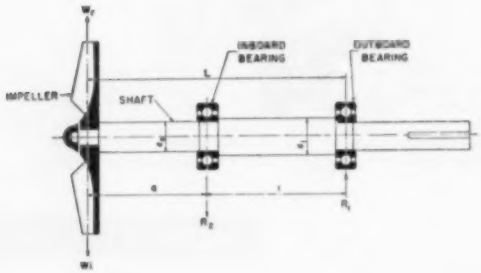

Fig. 6. Impeller, shaft, and bearing assembly for overhung-type centrifugal pumps.

AXIAL LOADS

Unbalanced axial load is present because the axial loads on each side of the impeller are usually different. The difference or the net axial load is:

$$T = T_s - T_{st} \qquad (13)^*$$

where T_s and T_{st} are the loads in pounds on the suction and stuffing-box side of the impeller respectively. Since the values for the calculated pressures are approximate, experimental measurements of pressures or experimental measurements of net axial load should be used whenever available instead of the pure calculated values.

Under the subject "Equations for Axial Loads," formulas are presented in the Appendix for the calculation of the axial load on each side of the impeller and for different types of impellers.

* Equations (14)-(15B) permit calculating the axial thrust on either side of both closed and semiopen impellers, with and without back vanes.

Pump Bearing-Bracket Assembly

The pump bearing bracket provides a major structural support. It supports the pump casing, holds the bearings that support the shaft for turning the impeller, carries all the hydraulic loads developed by the impeller, and supports the weight of the impeller and the shaft.

PIPE SUPPORT

As a rule, the bearing bracket is not designed to carry loads created by the weight of the pipe connected to the pump's suction and discharge nozzles or additional pipe strains resulting from the effect of pressure and temperature. All pipe connected to the pump should be supported near the pump or a flexible connection should be installed between the pipe and the pump nozzles to remove all possibilities of pipe strain.

PUMP SUPPORT

Two methods are used for mounting the pump and its bearing bracket on the base plate or foundation. One method has the one and only support under the bearing bracket. This leaves the casing in an overhung position with respect to the foundation. This is a customary type of support for the chemical process pump. The other method has the main support attached at the horizontal centerline of the casing. This is done by mounting two posts on the base plate on each side of the casing. A flexible auxiliary support is mounted on the base plate under the bearing bracket. This arrangement allows the pump to handle liquids at high temperatures with the minimum effect from thermal expansion. The pump casing expands radially and axially from the centerline of its axes. This type of support is used on heavy-duty pumps for refinery process and other high-temperature and pressure services.

STRENGTH OF BEARING-BRACKET COMPONENTS

Experience has shown that the cast-bearing-bracket structure is usually of sufficient strength to support the loads developed in the pump, but the shafts and bearings are often inadequate. Therefore, it is necessary to calculate bearing loads, bearing life, and shaft deflection to determine the adequacy of the shaft and bearing design. It is possible to do this when the axial and radial loads developed by the impeller can be calculated or measured experimentally. Other factors, such as static and dynamic balancing of impellers, and the critical speed for the pump shaft are also considered as a part of the bearing-bracket design.

BEARING LOADS

The radial load in pounds on each of the bearings shown in Figure 6 are calculated from the following beam equations:

For the inboard bearing

$$R_2 = \frac{LW}{l} \qquad (16)$$

For the outboard bearing

$$R_1 = \frac{aW}{l} \qquad (17)$$

where

$W = W_i + W_r$ (for vertical loads only)

W_r is fixed relative to W_i and is negative when the load is vertically downward. The bearing designated as the thrust bearing carries the axial load as calculated from Equation (13). If the direction for W_r is not vertical or close to the vertical and the impeller weight W_i is large in comparison to W_r, the vector sum for the maximum value of W should be used.

BEARING LIFE

According to the literature if ball bearings are properly mounted and lubricated, they will fail only because of fatigue due to repeated stress in the

Table 1.—Statistical Life Span for Ball Bearings

Life Attained	Symbol	Total Failed (Per Cent)	Life Spans (Years)		
Minimum	L_v	10	0.01	0.1	2.0
Average	$5L_v$	60	0.05	0.5	10.0
Maximum	$20L_v$	97	0.20	2.0	40.0

material. Under a given load and speed, a group of bearings of the same size and construction will have a range of lives from a minimum to a maximum. If a sufficient number of bearings is tested, the average life will be approximately five times the minimum life. The maximum life will be approximately twenty times the minimum life. Ten percent of the bearings will have failed when the minimum life is reached, sixty percent will have failed when the average life is reached, and about ninety-seven percent of all the bearings will have failed when the maximum life is reached. Table 1 * illustrates the bearing life span in terms of years.

The bearing life is calculated by a method described in the Appendix or by the bearing manufacturer's method. For a given load on equivalent bearings from different manufacturers, the values computed by their methods may differ widely. A study of the literature and manufacturers' catalogues on bearings shows that these differences are due to variations in the application of the bearing laws, interpretation of equivalent radial load for a combination of radial and axial loads, and in some cases, differences in bearing design. This matter is discussed more fully in the Appendix under the subject "Present Status of the Bearing Manufacturers' Literature," "Bearing Life Equations," etc.

RECOMMENDED BEARING LIFE FOR CENTRIFUGAL PUMPS

According to statistics † the life for a large number of bearings carrying the same load, will vary over a wide range. The user of bearings cannot tell by experience whether the bearings are overloaded for the life desired. However, if the calculated life span of a bearing is low (0.01 to 0.20 year equivalent to 4 days minimum to about 80 days maximum), it may be expected that actual service life would be close to the prediction.

For chemical and refinery processes, centrifugal pumps of the volute type, where the combined radial and axial load is the greatest at or near closed discharge, the minimum bearing life should not be less than about 2.0 years. Whereas the pump will not be operated at closed discharge continuously, operation of it, over the range of zero to about 50% of its capacity at the maximum efficiency point, can be considered for practical purposes the same as closed discharge operation. For centrifugal pumps with circular casings, the maximum radial load occurs near the maximum capacity of the pump. For this type pump, the point on the capacity curve where the effect of the combined radial and axial loads is the greatest should determine the size bearing to use. Elastic deformation takes place in the ball bearing when it supports a load. As the load increases, the amount of deformation increases. The radial component of the deformation can become important because it allows the shaft to deflect. This deflection is in addition to the bending of the shaft by the load on it. It may be necessary to use a bearing of larger size and greater load-carrying capacity in order to keep the amount of deformation to a minimum. If this change is necessary, there will be a substantial increase in the minimum bearing life. This matter is discussed in the Appendix under "Shaft Deflection."

* Table 2 is included in the Appendix.

† Equations (18)-(18F), together with sample calculations, are given in the Appendix to illustrate the calculation of bearing life.

Shaft Deflection

The deflection of the shaft at the impeller centerline is due largely to the net radial load for the impeller weight and the unbalanced radial load. Additional movement or deflection of the shaft will take place because of dynamic unbalance in the impeller, internal looseness, and elastic deformation in the ball bearings supporting the shaft. The amount of shaft deflection at the impeller under operating conditions must be limited. This limitation is fixed by clearances in the pump casing and the stuffing-box packing requirements.

For a freely supported shaft with two major diameters, the approximate static shaft deflection at the impeller in inches (neglecting shoulders and other minor changes in the cross-section of the shaft—see Figure 6) can be calculated for the net radial load present from the equation:

$$Y_{max} \frac{W}{3E}\left[\frac{a^3}{I_a} + \frac{a^2 l}{I_t}\right] \qquad (19)^*$$

where

$W = W_t + W_r$ (for vertical loads only)

$I_a = \frac{\pi d_a^4}{64}$ = moment of inertia for the shaft at the overhang

$I_t = \frac{\pi d_t^4}{64}$ = moment of inertia for the shaft between the bearings

For the uniform shaft, $I_a = I_t$ and Equation (19) becomes:

$$Y_{max} = \frac{W}{3EI}[a^3 + a^2 l] \qquad (19A)$$

In the case where pump shafts have sleeves, the diameter of the solid shaft under the sleeve is used to calculate I_a or I. Most sleeve designs do not appreciably stiffen the shaft assembly unless they are compressed.

The approximate shaft deflection at the centerline of the impeller for a shaft of multicross-section at the overhang or three major diameters (see Figure 7) is given by the following equation:

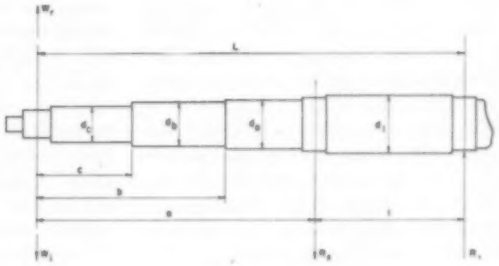

Fig. 7. Multicross-section shaft for overhung-type centrifugal pumps.

$$Y_{max} = \frac{W}{3E}\left[\frac{c^3}{I_c} + \frac{b^3 - c^3}{I_b} + \frac{a^3 - b^3}{I_a} + \frac{a^2 l}{I_t}\right] \qquad (19B)$$

Equations (19), (19B), and Figures 6 and 7 show that Equation (19B) can be modified to take care of a decrease or an increase in the number of major changes or even minor changes in shaft diameter at the overhang.

The effect of increasing the shaft diameter to obtain greater stiffness is of interest. Since the shaft stiffness is directly proportional to the moment of inertia, which in turn varies as the fourth power of the shaft diameter, a 20% increase in the shaft diameter results in an increase of the shaft stiffness by a factor of two. If this increase in diameter is applied to all sections of the shaft in the above equations, the deflection is reduced one half.

The effect of looseness in the bearing and deformation in the bearing is discussed and evaluated in the Appendix under the subjects "Deflection of the Shaft at the Inboard Bearing" * and "Shaft Deflection Measurement."

* Equation (20), relating bearing compression with load, is included in the Appendix.

Continued

CALCULATED AND EXPERIMENTAL VALUES FOR SHAFT DEFLECTION

Experimental measurements of shaft deflection of ten pump manufacturers' sleeve-type shaft assemblies without the sleeves have shown that the calculated values for radial load will be lower than the experimental values.* This occurs because the larger diameter of the shaft at a change in cross-section is not fully effective for some distance from the change. Equation (19B), modified to suit all changes in the solid shape of the shafts tested, was used to obtain their calculated deflection values. The experimental shaft-deflection values were plotted against the load on the shaft. A straight line was drawn through the data and the slope of the line determined. This procedure excluded the effect of any looseness in the bearings and the housings but included the effect of elastic deformation in the bearings. The experimental deflection values ranged from 10 to 50% greater than the calculated values from Equation (19B). When the calculated values for the effect of elastic deformation at the centerline of the load are subtracted from the experimental deflection values, the resulting values ranged from zero to 25% greater than the calculated deflection values. The latter percentages reflect the lack of shaft stiffness at the changes in cross-section for shafts. The difference between the two groups of percentages reflects the effect of elastic deformation in the bearings. The minimum bearing lives for the loads applied to the shafts in the comparison were all beyond nine years.

MAXIMUM ALLOWABLE SHAFT DEFLECTION

The maximum allowable deflection of the shaft at the impeller mounting is governed largely by the following factors:

1. Internal dimensions, especially wearing-ring clearances.

Since the radial wearing-ring clearances for the chemical-process pumps will range from about 0.005 to 0.010 in., the maximum shaft deflection at the impeller should be less than these clearances. Wearing rings should not function as bearings. They are leakage joints. As explained under "Bearing Life," maximum shaft deflection for volute-type pumps remains nearly the same for a considerable range in capacity as that at closed discharge.

2. Allowable deflection of shaft where it leaves packing.

Leakage from the centrifugal pump is controlled by the packing in the stuffing box or by other means. In the case of the packed stuffing box, the packing is compressed by the gland follower and squeezed into contact with the shaft. Rotation of the shaft develops heat by rubbing friction, and wear of the packing occurs where it is in contact with the shaft. As this wear continues, a clearance is created between the packing and the shaft. The amount of clearance may be determined by the shaft runout or whip and the shaft deflection present. Through this clearance liquid can flow from the stuffing-box side of the pump or from the lantern ring in the stuffing box. In the latter case, a liquid or a grease is introduced to the lantern ring from outside the pump. The liquid can come from a high-pressure point in the pump or some other suitable liquid can be introduced to the ring. A supply of liquid or grease is essential for lubricating the packing and the shaft. However, the packing allows the formation of a running fit with a close clearance to restrict leakage of the lubricant.

In order to limit the leakage from the stuffing-box, the shaft must be straight and shaft deflection limited. Whip or runout can be kept to less than 0.001 in. by checking the straightness of the shaft and the balance of the impeller. Shaft deflection is controlled largely through the use of a large enough shaft diameter for the load. If the maximum deflection at the impeller is limited to 0.005 in., the maximum deflection of the shaft as it passes through the packing would range from about 0.004 to 0.002 in. Excessive shaft deflections account for the unavoidable scoring of shafts and shaft sleeves because the packing is tightened to stop excessive leakage. Such shaft deflection probably accounts for leakage between the sleeve and the shaft when the impeller rides on the wearing rings. Under these conditions the joint between the impeller and the shaft sleeve opens up on the tension side of the shaft at each revolution.

For the cases where the wearing-ring clearances are large and the end of the packing is closer to the inboard bearing than half way, the deflection of the shaft at the end of the packing should be calculated. The wearing-ring clearance or the shaft deflection at the packing, whichever controls, should limit the deflection at the impeller.

3. Allowable deflection of shaft with mechanical seals.

When mechanical seals are used, the stuffing-box packing requirements for shaft deflection apparently do not apply. The Durametallic Corporation has carried out some experimental work on the effect of shaft deflection on mechanical seal performance. This work indicates that mechanical seals with Teflon packing can be operated with shaft deflections in excess of the limits indicated above.

One pump manufacturer expressed the opinion that even though mechanical seals can be operated with high shaft deflections, shaft deflection should be held to a minimum, even to the extent of being the limiting factor rather than the wearing-ring clearance. Operating seals with large shaft deflections shorten the life of a mechanical seal.

4. Materials of construction.

If the wearing-ring clearance and the packing requirement are ignored—and these do happen, wear at the wearing rings or the leakage joints becomes important when the surfaces are constructed of materials that will not function satisfactorily as bearings. While the impeller rides on the casing at the leakage joint, wear takes place; thus the small bearing area increases until it becomes large enough so that the impeller is seized and stopped suddenly, with breakage of the shaft at the impeller mounting or with failure of the bearings.

CRITICAL SPEED

The critical speed for an impeller-shaft assembly is of interest when it is in the range of the operating speed of the pump.

For end-suction centrifugal pumps of adequate mechanical design, it will be shown here that their critical speeds should be above 6,000 rev./min. and need not be of any concern.

A rotating pump-shaft assembly has a natural period of vibration. If the assembly rotates at a speed corresponding to its natural frequency, any minor unbalance is magnified. Operation of the pump without liquid in the casing at or near the critical speed may cause trouble.

When the pump is operated at the critical speed, the shaft should theoretically break (*9*). Actually, the clearances around the pump shaft and impeller limit the amount of deflection and only violent vibration can occur. With liquid in the pump casing and packing in the stuffing box, such vibrations are dampened.

Neglecting the effect of the coupling and the driver, the first or lowest critical speed for the pump shaft can be calculated from the following equation:

$$n_c = \frac{30}{\pi}\sqrt{\frac{g}{y_i}} \qquad (21)^*$$

If the shaft deflection due to the weight of impeller is less than 0.002 in., the critical speed for a completely balanced impeller will be above 4,200 rev./min. If the shaft

* Equations (19C)-(19E), providing a detailed elaboration method for calculating shaft bending at inboard bearing and radial load from shaft deflection measurements, are included in the Appendix.

* Equations (22)-(22B), concerning shaft whip from dynamic unbalance are included in Appendix.

is of adequate design so that the maximum deflection due to unbalanced radial load (constant $k = 0.36$) does not exceed 0.005 in. at the impeller centerline, the weight of the impeller for speeds of 1,750 rev./min. and greater, will usually be less than one-fifth the unbalanced radial load developed by the impeller.

Although not included in the end-suction class of pumps under consideration in this paper, pumps of good design in other classes are operated above and below the critical speed. However, the manufacturer designs the shaft-impeller assembly so that the operating speed is not an even fraction or multiple of the pump's first critical speed.

STATIC AND DYNAMIC BALANCING OF IMPELLERS

When the center of gravity for an impeller does not coincide with the center of the shaft's axis, a centrifugal force is developed which causes a dynamic deflection of the shaft. This deflection is in addition to the static deflection caused by the impeller's weight and to any unbalanced hydraulic radial load developed by the impeller.

All centrifugal pump impellers should be balanced statically to keep eccentricity in the impeller to a minimum and to prevent shaft whip or whirl by unbalanced mass distribution in the impeller. Static balancing, however, removes unbalanced static moments but does not remove unbalanced dynamic moments; the latter can be detected only by use of the dynamic-balancing machine.* The larger size impellers, especially when operated at the higher speeds, need to be balanced dynamically.

Other Evaluation Factors

SHAFT RUBBING SPEED

Pumps operating at 3,500 rev./min. should for most applications be as satisfactory as those operating at 1,750 rev./min. The common arguments against the use of 3,500 rev./min. for chemical process pumps stem from the fact that the rubbing speed (peripheral shaft velocity) being higher at 3,500 rev./min., is believed to shorten the packing life and to increase the temperatures at the shaft surface with the attendant fire hazard for flammable liquids. Actually, peripheral speed is only a relative matter, depending on various factors, and it will be shown that pumps can be operated satisfactorily and with safety at 3,500 rev./min.

Undue emphasis has been placed on the bad effects of the 3.500 rev./min. speed, whereas it can be shown that large-size, low-speed pumps can have as great or greater peripheral shaft speeds as the smaller high-speed pumps.

If a 1,750 rev./min. and a 3,500 rev./min. pump of similar design have shaft diameters large enough for the same service so that the shaft deflections are equal, the 3,500 rev./min. pump would have a rubbing speed 41.4% greater than the one running at 1,750 rev./min. but the heat developed by rubbing friction between the shaft and the packing would be the same for both pumps. It was assumed that the 1,750 rev./min. pump would have an impeller width and diameter twice that for the 3,500 rev./min. pump and that all other factors were equal. When leakage is present, the heat developed by fluid friction and the leakage rate depend on the clearance between the shaft and the packing. With the same assumption as above, including clearances and viscosities, the high-speed pump will develop 41.4% more heat than the low-speed pump, but the quantity of heat from fluid friction would be at a lower level than that developed by rubbing friction. Experimental measurements on power consumption confirm this fact. For similar assumptions, the leakage rate from the low-speed pump should be 41.4% greater than that for the high-speed pump.

The important factors that account for these statements are: (1) the low-speed pump would have a shaft diameter 41.4% larger than that for the high-speed pump. (2) Heat developed by rubbing friction depends on the first power of the speed and the second power of the shaft diameter. These two factors compensate so that the heat developed by rubbing friction is the same for both pumps. (3) Heat developed by fluid friction depends on the second power of the speed and the third power of the shaft diameter. The result is that 41.4% more heat is developed with the high-speed pump. (4) Leakage rates depend on the first power of the shaft diameter. It is obvious that there would be 41.4% more leakage from the low-speed pump.

Pressure on Packing

Although rubbing speed deserves attention, a more important but less recognized cause of high temperatures developing between the packing material and the shaft is the effect of the pressure on the packing. Also large shaft deflections contribute to the problem of preventing excessive leakage from the stuffing box. Incorrect mechanical design and assembly of the pump can lead to endless packing trouble regardless of the operating speed.

It has been observed that with low pressures in the stuffing box, the packing can be run in without any difficulty. If the packing had not been installed properly, or the gland follower is bolted up too tight, or the pressure in the stuffing box is raised to a high level, the packing is squeezed against the shaft by the pressure and a great deal of heat can be developed. Under these conditions leakage and normal lubrication of the shaft and the packing cannot take place until the packing is worn away and/or the lubricant in the packing is melted and flows out of the stuffing box.

Effect of Shaft Deflection on Packing

When large shaft deflections occur and the capacity of the pump is varied by the operating conditions, the unbalanced radial load changes and a corresponding change in shaft deflection takes place. This movement of the shaft deforms the packing and excessive leakage is present. The operator attempts to reduce this leakage by tightening the packing which results in squeezing the packing to the new position of the shaft. When this is done, even with great care, considerable heat develops and water must be poured over the outside of the stuffing box and shaft. Any change in the pumping rate would require further tightening of the gland to reduce leakage. Under these conditions the shaft or sleeve is likely to be scored and eventually must be replaced or repaired. Also, the repacking of the pump will be frequent.

PUMP (ROTATIVE) SPEED

If centrifugal pumps are of adequate mechanical design, their speeds, at least up to 3,500 rev./min, should be acceptable for the ordinary applications in chemical plants and oil refineries. However, certain exceptional conditions such as entailing erosion and/or low NPSH requirements may dictate that lower speeds should be used.

High-speed pumps of adequate mechanical design have the major advantage of being lower in cost than low-speed pumps of equal hydraulic design because of their smaller size. Then too, they are likely to have higher efficiencies, their maintenance costs should be lower because of the smaller size of the parts to be replaced, and the motors may be smaller because of higher efficiencies.

PROTECTION OF BEARINGS

Bearings cannot be expected to perform their duty properly if they are not lubricated and protected from dirt and other contaminants. Excessive application of grease or oil to the bearings results in overheating due to the churning of the lubricant. The bearing manufacturer's recommendations for proper methods of application should be followed closely.

The bearings are protected by the use of outside slingers, seals, and closures. The outside slingers are mounted on the shaft and are intended to throw off any solid or liquid particles that come near the bearing. The seals and closures perform a dual function of retaining the lubricant and excluding dirt, liquids, fumes, and gases.

* An analytical study of dynamic balancing is presented in the Appendix under the subject "Calculated Shaft Deflection or Whip for Dynamic Unbalance." Includes Equations (22)-(22b).

EVALUATING CENTRIFUGAL PUMPS

Continued

Figure 8 illustrates the types of slingers, seals, and closures in common use on centrifugal pumps. The plain type of slinger and seal obviously offer the least amount of protection. As the slinger and seal design becomes more complicated, the sealing devices become more effective, but shaft stiffness, concentricity, finish and surface hardness must meet closer tolerances.

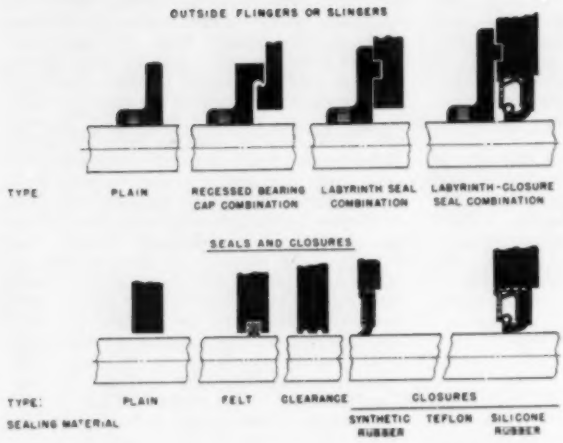

Fig. 8. Typical protective devices for pump bearings.

Surface Requirements

Those surfaces of the shaft coming in contact with the packing and the flexible sealing element of bearing closures should have the maximum hardness and finish that it is practical to provide.

Manufacturers of closures recommend a surface hardness of Rockwell C 30 to 40 (approximately 300 to 400 Brinell) and a shaft finish not to exceed 20 micro-inches in roughness. For high speeds lower values in roughness are desirable.

The surface hardness is obtained by the selection of suitable materials of construction for the solid or sleeve-type shaft construction, supplemented by heat treatment, surface hardening, chrome-plating, Stellite or similar material for facing or overlay, or Stellite half sleeves welded together on the shaft to give a shrink fit.

Allowable Mounting Temperatures

The Bearing manufacturers do not state in their literature what the maximum allowable operating temperature should be. However, for heating bearings with hot air to mount them on a shaft, they do recommend that the temperature be kept below 180° F. so that the bearing parts (balls and rings) will not be softened. When the bearings are heated in an oil bath jacketed with low-pressure steam, the oil temperature will be above 200° F. A recent article (*2*) states that the oil temperature, for heating bearings, should be kept below 300° F. SKF Industries, Inc., recommends that heating the bearings to 200° F. should be adequate.

Allowable Operating Temperatures

Cooling of the bearing lubricant is usually required if the temperature in the pump casing exceeds 300° F. This is accomplished by jacketing the stuffing box and the bearings. The bearing housing should not be jacketed, however, if the result is a large differential temperature between the inner and outer race and internal tightness of the bearing. If more convenient, a cooling coil in the oil reservoir can be used as a substitute for the jacketing of the bearings. For obvious reasons, bearings should be operated at temperatures as low as practical. SKF further recommends that for operating temperatures greater than 250° F., selected heat stabilized bearings and proper lubricant should be used.

All the seals shown on Figure 8 are suitable for operation with lubricant temperatures up to at least 200° F. and shaft speeds up to 3,500 rev./min. or 3,000 ft./min. of shaft surface speed.

STUFFING-BOX DESIGN

Stuffing-box design for the ordinary chemical process pump has become established so that there is room for five rings of packing and one lantern ring for lubrication of the packing. Deep stuffing boxes with a larger number of rings of packing are generally no more effective than ones with a few rings. This is true because only the first few rings of the packing are compressed by the gland follower. For some conditions with temperatures above 250° F. the stuffing box is jacketed to protect the packing. High-temperature and high-pressure pumps are equipped with a deep stuffing box, usually with seven to eight rings of packing, a throat bushing, a lantern ring, and a smothering-type gland follower for quenching flammable liquids.

The face of the gland should be flat and at a right angle to the axis of the shaft. The face should not be beveled. It seems evident that a follower with a beveled face increases the possibilities for scoring the shaft when the packing is compressed excessively. The gland and the lantern ring should be split so that the mechanic can remove them and have room to install the packing. For high pressures on the stuffing box, the gland should be of the four-bolt, locking-split type held together with two cap screws. To prevent extruding of the packing, the gland should have a loose sliding fit into the bore of the stuffing box and its bore should have a radial clearance of about 1/64 in. with the shaft.

MECHANICAL SEALS

Most of the available chemical process and refinery pumps can have the packing replaced with a mechanical seal. The seals are available as single and double inside units and a single outside unit. Some manufacturers have pumps available with an integral mechanical seal design. Since the seal requires less space than the packing, the length of the pump at the overhang is shortened.

Unbalanced mechanical seals can be used with pressures in the stuffing box up to about 75 lb./sq. in. Seals of the ordinary balanced type are adequate for pressures up to about 600 lb./sq. in. and temperatures up to 450° F. Seals are available for higher pressures and temperatures but they are of special design. A throttling gland and bleed-off in the bottom of the stuffing box and a cooling liquid makes it possible to use the seal or packing for higher pump pressures and temperatures.

It is important that pumps equipped with mechanical seals and operating with high stuffing-box pressures, have a stuffing box that uses at least four gland bolts of adequate size and a throat bushing properly installed. The throat bushing should have a close clearance with the shaft so that if the mechanical seal should fail suddenly, leakage from the pump is controlled. Serious fires have resulted after converting pumps with packing to mechanical seals and not installing the proper throat bushing and checking the bolt size to prevent failure at the gland.

Assembly of Pumps

In the repair, assembly, and installation of pumps the manufacturer provides general instructions which should be followed with care. These instructions usually include methods for setting the

pump in place, alignment of the pump and motor shafts for the coupling, and precautions to be taken in connecting piping to the pump.

In the repair and reassembly of pumps there are some requirements that are not always met by the pump mechanic. Bearings should be mounted on the shaft and this assembly placed in the bracket so that the bearings are not damaged. Instructions of bearing manufacturers should be carefully followed in heating the bearings and pressing them in place.

All parts of the shaft must be machined true to dimensions, particularly the shaft shoulders and bearing seats, because if these parts are out of square, sharp bending can occur when the inner rings of the bearings are locked up by the shaft nut. The run-out or out-of-roundness at the impeller mounting should be less than 0.001 in. Remounting of old shafts should be checked also since they have been found with too great a run-out.

Impellers should always be statically balanced and those operating at 3,500 rev./min. may need to be checked dynamically. The balancing should be carried out to the extent that the run-out of the rotating impeller-shaft assembly is less than 0.001 in.

For semiopen and open impellers and impellers with back vanes, the casing walls should be checked to see that the wall surfaces are flat to within about several thousandths of an inch if the clearances are to be around 0.015 in. The impeller vanes must likewise meet such requirements and the impeller must be mounted on the shaft so that it will not cock one way or another. The practice of installing an impeller and turning it over by hand to see if it strikes the casing should be supplemented with more use of dial and feeler gauges. A soft wire, such as fuse wire, can be used to measure the clearances between the impeller vanes and the casing wall.

In the case of pumps of alloy construction, such as stainless steel in which galling takes place easily, the above-mentioned requirements must be met so that under normal operating conditions and over the capacity range for the pump, except for the packing or mechanical seal, the rotating parts of the pump do not touch the stationary parts. This is especially important in acid service since it is well known that the endurance limit drops to low values when metals are in contact with corrosive liquids. Any unnecessary loading or stressing of the shaft in the pump casing may lead to its early failure.

Case Examples of Pump Performance

The following material is not a result of planned research or investigation of pump failures but represents initial efforts in becoming familiar with the problems present. Evaluation of the mechanical design in pumps depended partly on the information available in the literature and partly on field measurements. It was not always possible to make measurements of the shaft deflection and the pressures in the pump casing at the same time. No sleeve-type shaft assemblies were in use and all shaft-deflection calculations and measurements were based on the assumption that the pump shafts have only two major diameters. No allowance was made for elastic deformation in the bearings.

The illustrations represent experiences with extreme cases which are a minority of the pumps purchased. No attempt should be made to identify the manufacturer of these pumps since similar illustrations can be shown for pumps from others. These and other pumps of inadequate mechanical design account for a substantial proportion of maintenance costs for all pumps.

Complete data describing the service in which the pumps were used are not given. Using pumps of the same design with water or a liquid of the density reported here should give similar results.

Table 3.—Pump A—Bearing Bracket Evaluation

Pump speed:	1750 rev./min.	Shaft diam.:	1.687 in. × 1.50 in.
Impeller diam.:	12.5 in.	Back-vane type:	Radial
Impeller width:	1.5 in. overall	Height of vane:	7/32 in. avg.
Capacity:	0 gal./min.	Back-vane clearance:	0.024 in.

Inboard bearing equivalent to SKF 6308
Outboard bearing equivalent to two SKF 7308

	Calculations based on discharge pressure	Experimental Measurements			
Pump capacity (gal./min.)	0	0	0	0	0
Sp. gr. of liquid	1.0	1.0	0.96	0.96	0.96
Pressures					
Suction pressure (lb./sq.in. gauge)	0	0	90	80	80
(ft.)	0	0	217*	193*	193
Stuffing box pressure (ft.)	21	63	280	259	259
Avg. volute pressure (ft.)	133	140 av.	357 av.		
Discharge pressure (ft.)	193	193	410*	419*	419
Calculated radial load at impeller					
Calculated by Stephanoff's formula (lb.)	563	563	540		632
Calculated from shaft deflection (lb.)				657	
Calculated radial load at bearings					
Inboard-life (lb.)	1390	1390	1332	1620	1557
Outboard-life (lb.)	826	826	792	961	927
Calculated axial loads					
Based on discharge head (lb.)	−458				
Based on experimental data (lb.)		−1467	−76	−280	−280
Calculated bearing life					
Inboard-life (yr. min. life)	0.14	0.14	0.16	0.09	0.10
Outboard-life (yr. min. life)	1.93	0.5	1.9	1.7	1.8
Shaft deflection					
Shaft deflection measured 6 in. from impeller centerline (in.)				0.00385	
Calculated shaft deflection at impeller centerline based on deflection measurements (in.)				0.0215	
Calculated shaft deflection at impeller centerline based on Equations (1) and (1A)	0.0185	0.0185	0.0177		0.207
Uniform shaft diameter required for y max. = 0.005 (in.)	2.22	2.22	2.19	2.30	2.28

* Measurements of total head developed by pump do not agree. They were taken about four months apart, apparently the vane clearances on the suction side of semiopen impeller were different giving different total heads.

Pump A

Pump A (Figure 9) was supplied as a test to see if it would give better performance than some ten other pumps of the same size with high maintenance records. The manufacturer had originally used an equivalent to SKF 6308 deep-groove-type bearing (Dynamic rating 6,950 lb.) for the thrust bearing. He replaced it with duplex bearings, equivalent to the SKF 7308 angular-contact-type with a dynamic rating of

12,500 lb. The impeller, the diameter of which was reduced from 13 to 12½ in., was equipped with back vanes to reduce axial load.

Table 3 summarizes the calculations evaluating the mechanical design of the bearing bracket (Figure 9). It should be noted that at zero suction pressure, the unbalanced axial load calculated from the measured casing pressures is very high; however the axial load determined from the calculated pressures in the casing is low. The reason is that the calculated stuffing-box pressures are lower than the measured values. This fact indicates how important it is to have experimental values when back vanes are present. At 90 lb./sq. in. gauge suction pressure, the unbalanced axial load is low. Bearing life is low for the inboard bearing and is also low for the outboard bearing at zero suction pressure when the axial thrust is high. The outboard bearing life is not low when the high suction pressure is present. The calculated shaft deflections of 0.018 to 0.022 in. are high. Shaft-deflection measurements check with those calculated by formula, which means the radial load present checks with that calculated from Equation (1) and the unbalanced radial load constant of 0.36 for a volute casing. This is shown in the table where the deflection calculated from the experimental measurement is 0.0215 and it can be compared with 0.0207 in. calculated by empirical methods. Both values are underlined in the table. The table also indicates that the shaft diameter should be increased to about 2.25 in.

Table 4 presents the maintenance history for Pump A, from March 1, 1951, to June 1, 1954. The loads are too high for the inboard bearing and the shaft deflection is high, as was just shown. The effect of the high shaft deflection is indicated mainly by the large number of mechanical seal failures. The average life for the inboard bearing is calculated to be about 0.70 year, at shutoff and the actual life for the inboard bearing averages 0.42 year, indicating that the experience and the calculations check reasonably well. The lower actual life is probably brought about by the high shaft deflection, which imposes the equivalent of an additional load on the inboard bearing by twisting the inner race.

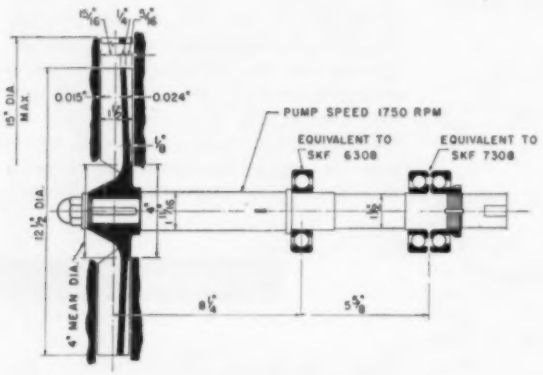

Fig. 9. Pump A as supplied by the manufacturer.

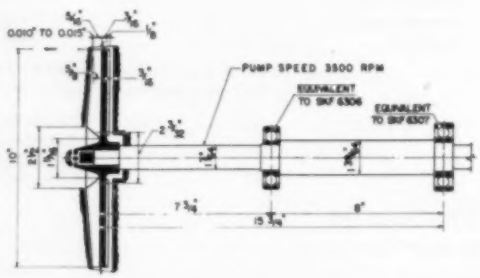

Fig. 10A. Pump B as supplied by the manufacturer.

Table 4.—Pump A—Maintenance History March 1, 1951 to June 1, 1954

Pump in operation	Pump out of operation	Operating interval (days)	Bearing life[1] (yrs.)	March 1, 1951 to June 1, 1954 — Kind of Failure: Bearings	Shaft	Impeller	Casing	Mech. seal	Remarks
3/ 1/51	3/30/51	29						X	Power failure 20 to 100 gal./min.
4/10/51	5/ 4/51	24						X	
5/17/51	8/ 8/51	83	0.37	X (Inboard)					
8/15/51	12/12/51	119	0.33	X (Inboard)					
12/26/51	1/10/52	15						X	Operation near closed discharge
1/16/52	2/ 2/52	17						X	Blow back pressure failed
2/12/52	6/ 1/52	109	0.30	X (Inboard)					50 to 200 gal./min.
6/10/52	2/10/53	245	0.67	X					35 gal./min.
2/13/53	6/29/53	136	0.37	X	X (Bent)			X	Intermittent operation
7/ 2/53	12/18/53	169	0.47	X				X	Intermittent operation
12/29/53				Continuous operation, no failure to date (6/1/54)					

[1] Capacity at maximum efficiency is 480 gal./min.—radial load is a minimum.
Calculated life for inboard bearing—0.14 year minimum life—0.70 year avg. life, avg. of actual life is 0.42 year.

Table 5.—Pump B—Evaluation of Bearing Brackets

Pump Speed 3500 rev./min. Impeller Width 0.625 in. Height of Vane: 1/8 in.
Impeller Diam. 10 in. Back-vane Type: Curved Sp. Gr. of Liquid: 1.0

	Experimental Data at Manufacturer's Plant					Calculated Data Based on Redesign of Pump and Discharge Pressure		
	Exp.	Calc.	Exp.	Calc.	Exp.			
Pump capacity (gal./min.)	0	0	95	95	121	0	95	120
Pressures								
Suction pressure (ft.)	0	0	0	0	0	0	0	0
Stuffing box pressure (ft.)	136	135	54	51	−22	18	−34	−34
Average volute pressure (ft.)	325	309	228	228	55	309	228	−10
Discharge pressure (ft.)	386	386	305	305	67	386	305	67
Calculated radial load at impeller (lb.)	376	376	0+	0+	−40	376	0+	−39
Radial load at bearings								
Inboard (lb.)	739	739	0+	0+	−79	773	0+	−80
Outboard (lb.)	364	364	0+	0+	−39	399	0+	−41
Calculated axial loads								
Back-vane clearance (in.)	3/16	3/16	3/16	3/16	3/16	0.030	0.030	0.030
Calculation based on discharge head (lb.)		−2430		−1050		−480	−430	+576
Calculation from experimental data (lb.)	−2450		−980		+340			
Bearing life								
Inboard—Equivalent to SKF No.	6306					NN3011K		
Life (yr. min. life)	0.15	0.15	<∞	<∞	125	1.6	<∞	1423
Outboard—Equivalent to SKF No.	6307					Three 7307		
Life (yr. min. life)	0.005	0.005	0.051	0.04	0.55	2.4	8.0	3.1
Shaft deflection								
Shaft diam. at overhang (in.)	1.11					2.0		
Shaft diam. between bearings (in.)	1.61					2.375		
Shaft deflection based on Equations (1) and (1A). (in.)	0.032	0.032	0.000+	0.000+	−0.003	0.0036	0.000+	−0.0004

Pump B

Pump B (Figure 10A) is one of two identical pumps supplied by a manufacturer for high-head low-capacity service. This pump has a semiopen impeller with back vanes on the back of the impeller. The vane clearance on the suction side of the impeller is shown to be 0.010 to 0.015 in., normal for a pump to develop the proper head. On the back of the impeller, the back-vane clearance is approximately 3/16 in. and is much too high for this pump. The back vanes cannot keep effectively the stuffing-box pressure low and a high axial load will be present. This pump was sold to operate at 3,500 rev./min. speed, but a check of the pump manufacturer's catalogue showed the pump to be offered only for the 1,750 rev./min. speed.

Table 5, an evaluation of the bearing bracket for this pump, is based on the assumption that the casing is of the volute type. Calculations are in two parts. The first part compares the experimental data obtained at the manufacturer's plant with the calculated values; the second part presents the calculated data based on the redesign of the pump.

Pump B failed so frequently in one month of operation that it was sent back to the manufacturer. It had five failures involving the bearings and the shaft. The pump continued to operate at the manufacturer's plant with high-bearing temperatures. The outboard bearing had the highest temperatures because it carried a high axial load in addition to the radial load. The pressures in the pump casing were measured. The net axial load calculated from the pressure measurements showed this load to be extremely high. The pressures in the pump casing were calculated, the values obtained checked the experimental data quite well. The unbalanced radial load at the impeller was calculated and with this value, the radial loads on the bearings were determined. The calculated inboard bearing life was low when the pump was operated at capacities less than the capacity at maximum efficiency. Because the axial load remains high, the calculated outboard bearing life was extremely low for all capacities up to the point of maximum efficiency. The shaft deflection was calculated and found to be very high. The pump manufacturer could not offer any other pump of suitable mechanical design as a replacement and so it was returned to the purchaser. We redesigned the pump, putting in a new stuffing box, larger shaft, and larger bearings.

No shaft deflection measurements were made on this pump as supplied by the manufacturer—all values shown are calculated from Equations (1), (1A), and (19). Recent measurements of shaft deflection by the manufacturer at 1,750 rev./min. indicate that this pump's casing acts as if it were of the circular type. The shaft deflection is a minimum at closed discharge of about 0.009 in. and increases with capacity to 0.036 in. at 90 gal./min. for the 3,500 rev./min. speed. The deflections measured at 1,750 rev./min. were one fourth of the above values. It should be clear that this pump is of extremely weak mechanical design for the 3,500 rev./min. speed.

The second part of the table shows the calculations for bearing life and shaft deflection for the redesigned pump, based on a volute casing. It is seen that the bearing life is adequate and the shaft deflection is low. If the calculations were carried out on the basis of circular casing design, the values for bearing life will decrease and for shaft deflection will increase with the capacity of the pump. At maximum capacity, the minimum value for bearing life and the maximum value for shaft deflection will be about the same as for the volute casing at closed discharge.

Table 5A presents the maintenance history for Pump B as supplied by the

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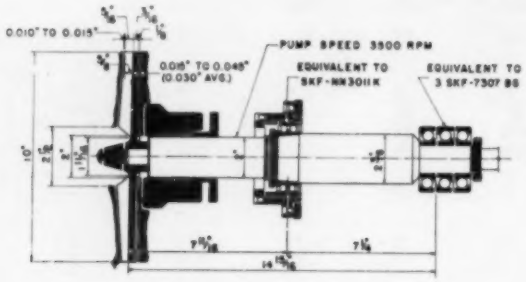

Fig. 10B. Pump B, redesigned with new stuffing box, shaft, and bearings.

manufacturer for the period of May 12, 1951, to June 8, 1951. The axial load was so high on this pump as supplied by the manufacturer, that the impeller nut was stripped off the shaft. Apparently, on reassembly of the pump by the mechanics, shaft deflection was great enough so that the impeller engaged the casing wall, causing the shaft to be sheared at the impeller mounting. After that the bearings failed repeatedly. The average bearing life for the outboard bearing was calculated to be 0.045 year. The actual average life was approximately 0.03 year, which checks quite well. At the bottom of the table, values are shown for the life of this bearing for back-vane clearances of 3/16, 1/8, and 1/16 in. These clearances are too large and the outboard bearing lives are too low.

Figure 10B shows a drawing of Pump B redesigned with a new stuffing box, shaft and bearings, and rebuilt in our shop. The shaft diameter was increased and bearings used as shown. A double cylindrical roller bearing was used in place of the single deep-groove bearing, in order to obtain a bearing with adequate load-carrying capacity and small enough to fit into the limited space available. The outboard bearings were replaced with three of the angular-contact type, two in tandem to take care of the high axial-thrust load towards the suction of the pump. The third bearing in the opposed position takes care of the lower reversed thrust when the pump is operating near the end of the performance curve. Note that the back-vane clearance has been reduced from 3/16 to about 0.030 in.

Table 5B gives the maintenance history of the rebuilt Pump B. From the period of May 11, 1952, to April 14, 1953, the actual life of the outboard bearing was increased from 0.03 year average to an average 0.4 year. The life for the outboard bearings in the rebuilt pump was calculated to be 2.4 years for operation near closed discharge and 3.1 years at maximum capacity. The lower actual life may be accounted for by the fact that the pump was not put back in its original high-head service but was used as a tank circulating pump and was subject to running off its curve with excessive cavitation. The other bearing failures shown, (and not included in the stated actual average life) were due to using unmatched angular-contact bearings by mistake and leaving out the packing support ring at the bottom of the stuffing box. The packing was sucked into the space between the back vanes and the casing wall damaging the back vanes and bearings. This happened because there is a vacuum in the stuffing box when the pump is operated out near the end of the performance curve.

When angular contact bearings are used in pairs or multiple mountings,

Table 5B.—Pump B—Maintenance History of Rebuilt Pump

May 11, 1952 to April 14, 1953

Pump in operation	Pump out of operation	Operating interval (days)	Bearing life (years)	Kind of Failure: Bearings	Remarks
5/11/52	10/14/52	156	0.4	X (outboard)	[1]
10/29/52	10/30/52	1		X (outboard)	[2]
11/16/52	11/17/52	1		X (outboard)	[3]
11/18/52	4/14/53	147	0.4	X	
4/24/53	Pump put in standby position				

[1] This pump was not put back into its original high head service, but was used as a tank circulating pump.
[2] Unmatched angular contact bearings were installed by mistake.
[3] Packing support ring left out of stuffing box and packing was sucked into space between back vane and casing wall damaging back vanes and bearings. Installed new impeller and machined casing wall for 0.030-in. vane clearance.

Table 5A.—Pump B—Maintenance History of Pump as Supplied by Manufacturer

May 12, 1951 to June 18, 1951

Pump in operation	Pump out of operation	Operating interval days	Bearing life years	Kind of Failure: Bearings	Shaft	Impeller nut	Remarks
5/12	5/25	13				X	stripped threads
5/25	5/30	5			X		shaft sheared at impeller mounting
5/31	5/31	11 hr.			X		loose nut entered suction
6/4	6/8	4	0.07	X			outboard bearing very hot
6/8	6/12	4	0.01	X			outboard bearing very hot
6/13	6/18	5	0.014	X			shipped pump back to manufacturer

Note: Calculated bearing life for outboard thrust bearing:

Back-vane clearance (in.)	3/16	1/8	1/16
Years min. life	0.009	0.013	0.033
Years avg. life	0.045	0.065	0.165
Years max. life	0.180	0.260	0.660

they must be purchased as flush-ground bearings. The side faces of the bearings are match-ground to permit mounting two or more bearings together; the data in Table 5-B show how quickly unmatched bearings will fail.

Extreme care must be taken in supporting the packing in the bottom of the stuffing box with a throat bushing or ring, especially if a high vacuum can be developed at the back of the impeller. If the ring's radial clearance with the shaft is not small, the packing can be sucked into the pump casing (as was done on November 17, 1952, with Pump B).

Pump C

Figure 11 shows one of five identical pumps with a volute-type casing and constructed of Hastelloy Alloy D with a Hastelloy Alloy C shaft. These pumps are used for one pumping operation.

Table 6 presents the calculated values for bearing life and shaft deflection for the capacity range of the pump from 0 to 290 gal./min. with the maximum efficiency at about 240 gal./min. For capacities below 200 gal./min., inboard bearing life is low and the shaft deflection is high.

Table 7 presents the maintenance history of these pumps as supplied by the manufacturer, for the period of June 11, 1951, to December 26, 1951, and January 17, 1953, to February 28, 1954. One pump was operated continuously, one spare pump mounted and ready, and three spare pumps were available as replacements. This table shows for the first period of 198 days of operation there were 22 failures, the average operating time for each pump being 9 days. In the second period of 407 days of operation there were forty-four failures, the average operating time being 9.3 days/pump. Failures were those of the bearings and the shaft. The shaft usually failed by breaking off at the impeller mounting.

The actual average bearing life for the operating conditions was about 0.025 year compared to the calculated average life of 2.0 years for the inboard bearing and 11.0 years for the outboard bearing. These failures should be blamed on excessive shaft deflection. Since the pump had a shaft deflection of about 0.023 in. in the operating range, the impeller rode on the casing wearing ring. The radial clearance at the wearing ring was about 0.008 in. Under these conditions the material galled and rapid wear resulted at the leakage joint surfaces. As soon as the worn area became large enough the impeller was seized at the wearing-ring surfaces and the shaft twisted off at the impeller mounting. This occurs because the kinetic energy, to be absorbed on sudden stoppage in

Table 6.—Pump C—Bearing Bracket Evaluation

Pump speed .....3500 rev./min.
Impeller diam. .....9.125 in.
Impeller width .....0.566 in.
Inboard bearing equivalent to ..SKF 6308
Outboard bearing equivalent to SKF 6308
Shaft diam. at overhang .....1.25 in.
Shaft diam. between bearings ..1.53 in.
Distance at overhang .....8.25 in.
Distance between bearings ....6.125 in.
Capacity at maximum efficiency .240 gal./min.
Sp. gr. of liquid 1.4

Capacity (gal./min.)	0	100	200	240	290
Head (from manufacturer's curve) (ft.)	356	352	330	312	244
Radial load at impeller (lb.)	415	339	118	0+	−133
Impeller weight (lb.)	−9	−9	−9	−9	−9
Net radial load (lb.)	406	330	109	−9+	−142
Bearing loads					
Inboard (lb.)	953	775	254	−21.7+	−334
Outboard (lb.)*	546	445	146	−12.5+	−192
Bearing life					
Inboard life (yr.min.life)	0.2	0.4	11.7	<19,200	5.2
Outboard life (yr.min.life)*	1.2	2.2	61.4	<97,200	27.0
Shaft deflection (in.)	0.028	0.023	0.007	>−0.0006	−0.010
Uniform shaft diam. required for y max. 0.005 in. at q = 0 gal./min.(in.)	2.1				

* Axial thrust is assumed to be negligible since both wearing-ring diameters are equal. Actually unbalanced axial thrust is present on the impeller areas under the wearing rings; the outboard bearing life will be lower than that calculated.

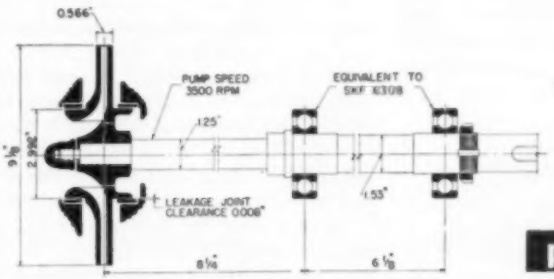

Fig. 11. Pump C as supplied by the manufacturer.

Table 7.—Pumps C-1 to C-5 as Supplied by Manufacturer—Maintenance History

Method of operation:
One pump operating continuously
One spare pump mounted and ready
Three pumps as replacements

Operating conditions:
Total capacity 80 to 190 gal./min.
Suction pressure 0 to 5 lb./sq.in.gauge
Discharge pressure 215 to 205 lb./sq.in.
Specific gravity 1.4

Pump No.	Number and nature of failures: Bearings	Shaft	Impeller	Casing	Number of pump failures	Operating time: Total (days)	Avg. (days/pump)
For period of 6-11-51 to 12-26-51							
C-1	5	5	1	0	5		
C-2	5	4	2	0	6		
C-3	5	4	1	1	5		
C-4	6	5	0	0	6		
	21	18	4	1	22	198	9.0
For period of 1-17-53 to 2-28-54							
C-1	6	6	3	1	8		
C-2	6	5	2	0	8		
C-3	12	10	5	1	13		
C-4	7	7	0	1	8		
C-5	5	7	3	1	7		
	36	35	13	4	44	407	9.3

Continued

the electric motor rotor and shaft assemblies is great enough so that the ultimate shear strength of the shaft at the impeller mounting can be exceeded by a large factor, about 13 for this pump shaft. This shows how important it is to have pumps with shafts stiff enough so that the deflection of the shaft will be less than the wearing-ring clearances. The short bearing life is probably due to high loads imposed on the bearings while the wear is progressing at the ring surfaces and the impeller tends to climb on the wearing rings. Excessive shaft deflection can twist the inner races of the bearings and create unduly high stresses in them.

Redesign of this pump was not undertaken by ourselves because of the major changes required in the stuffing box, shaft, and bearings; however, new pumps of adequate design have been developed with the pump manufacturers, and two new pumps have been purchased.

Table 8.—Pump D—Maintenance History

Method of operation: One pump operating continuously; One spare pump mounted and ready

Operating conditions: Capacity 100 gal./min.; Suction pressure 0 lb./sq.in. gauge; Discharge pressure 260 lb./sq.in. gauge; Sp. gr. 1.4

Shaft diam. at overhang	Shaft diam. between bearings	Number and nature of failures: Bearings	Shaft	Wearing ring replacement	Number of failures	Operating time: Total (days)	Avg. (days/pump)
Pump as supplied by manufacturer 3/1/52 to 4/24/52							
1 7/16 in.	1½ in.	2	4	1	5	54	10.8
Pump shaft diam. increased 5/3/52 to 9/4/52							
1.94 in.	1.96 in.	4	6	2	9	124	13.6
Pump bearing bracket redesigned and rebuilt with larger shaft and bearings 9/15/52 to 10/15/53							
2⅛ in.	3¼ in.	5	10	6	17	359	20.1
		10/15/53 to 3/5/54*					
		0	0	0	0	141*	....

* Pump continuing in operation.

Pump D

Pump D (Figure 12A) is of weak design. The liquid end is of Hastelloy C construction. This pump operated in the same service in another location with three pumps of the same size and construction as described for Pump C. The maintenance history for the three pumps in this location was the same as previously described for Pump C.

Figure 12B illustrates approximately how the bearing life and the shaft deflection for a volute-type casing varies with the pump's capacity. The calculated shaft deflection is extremely high, almost twice that for Pump C. The calculated inboard bearing life is low. The radial clearance at the wearing rings for this pump is 0.010 in. For a maximum shaft deflection of 0.010 in. and minimum bearing life of 2.0 years, the graph shows the allowable safe capacity range for operation to be about 230 to 270 gal./min. This is well beyond the normal operating capacity of 100 gal./min.

Table 8 gives the maintenance history for this pump for four periods. In the first period the pump had five failures in 54 days (or 10.8 days average operating time between failures) with the shaft and bearings as supplied by the manufacturer. After the failure of April 24, the shaft diameters were increased in size to 1.94 in. at the overhang and to 1.96-in. diam. between the bearings. The bearings were changed to a lighter series for mounting on the larger shaft.

In the second period the average operating time between failures was increased to 13.6 days with the heavier shaft. The shaft and bearings failed for the same reasons as given for Pump C, namely the impeller was seized at the wearing surfaces, causing either the breakage of the shaft or the failure of the bearings or both.

Between the second and the third operating periods, Pump D was redesigned and rebuilt in our shop (see Figure 12C). The inboard bearing arrangement was that suggested by the manufacturer. As can be seen, the shaft diameters were increased from 1 7/16 to 2⅛ in. at the overhang and between the bearings from 1½ to 3¼ in. At the same time the overhang was reduced from 13 in. to 10½ in. for the corresponding increase in the distance between the bearings. All these changes were in the direction of improving bearing life and of reducing shaft deflection by lessening the load on the bearings

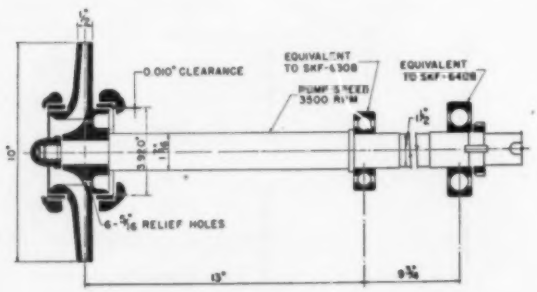

Fig. 12A. Pump D as supplied by the manufacturer.

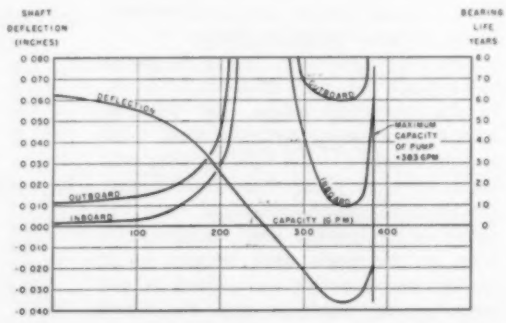

Fig. 12B. Pump D with 10-in.-diam. impeller, calculated shaft deflection, and bearing life for pump as supplied by manufacturer.

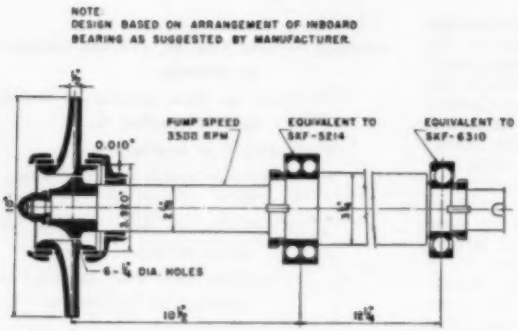

Fig. 12C. Pump D, redesigned and rebuilt in purchaser's shop.

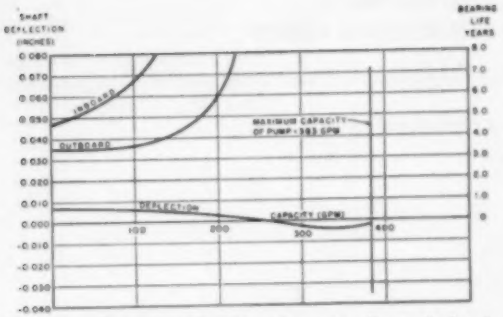

Fig. 12D. Pump D with 10-in. diam. impeller, calculated shaft deflection, and bearing life for pump as redesigned by purchaser.

and the overhang. Although the drawing does not indicate it, the distance between the stuffing box and the inboard bearing was very short. The room for introducing the packing was too small for convenience, however the pump could still be packed.

Figure 12D illustrates the evaluation of the design of the rebuilt pump. The bearing lives have increased and the shaft deflection decreased. Minimum bearing lives are above two years; shaft deflection is about 0.007 in. at closed discharge and for a considerable distance out on the curve. Since the wearing-ring radial clearances for this pump are 0.010 in. and the shaft leaves the packing at a point close to the bearings, its deflection at both points should not be serious.

The third period on Table 8 gives the maintenance history of the rebuilt Pump D. From September 15, 1952, to October 15, 1953, there were seventeen failures in 359 days with the average time in operation between failures of 20.1 days. The reasons, according to the records, were bearing failures, broken and bent shafts, and wear at the wearing rings. These failures are indicative of the problems encountered with maintenance repair procedures.

A procedure was developed and steps were outlined for checking clearances and dimensions while the pump was being assembled. The record for the fourth period, with no failure in 141 days, indicates that these problems are being solved.

Pump E

Table 9 presents the bearing bracket evaluation for a pump of the end-suction type. The pressures in the casing were measured and the unbalanced axial thrust calculated. Both bearing temperatures were measured with thermocouples. This pump was used to transfer materials to the shipping department and to circulate a storage tank. In both cases the discharge heads on the pump were less than the head of 120 ft. developed by it at a maximum capacity of 180 gal./min. These data show that this pump, which is of weak design, or any other pump of good design, should not be operated off the performance curve without risk of damage to the pump; in addition the pumping rate or capacity would be reduced drastically.

The pump was received from the manufacturer with much lighter bearings than those listed in the table. Both bearings were of the type and size equivalent to SKF 1207. After frequent failures, the pump mechanics installed the heavier bearings. At present the bearing life is not too low, but the shaft deflection is very high at low pumping rates. This pump has a leakage joint on the suction side of the impeller with a radial clearance of about 0.030 in. Except for some slight resistance by the packing in the stuffing box, the shaft can deflect freely up to 0.030 in.

The inboard bearing temperature is very high and increasing at closed discharge and is high again at the end of the curve where the pump is cavitating. The outboard bearing temperature re-

Table 9.—Pump E—Bearing-Bracket Evaluation and Bearing Temperatures

Pump speed ..... 3500 rev./min.
Impeller diam. ..... 8.0 in.
Impeller width ..... 0.875 in.
Inboard bearing equivalent to SKF No. 5307
Outboard bearing equivalent to SKF No. ..... 2-7207 BG
Sp. gr. of liquid 0.98

Shaft diam. at overhang .... 1.468 in.
Shaft diam. between bearings 1.375 in.
Shaft length of overhang ... 8.312 in.
Shaft length between bearings 6.531 in.
Date of measurements 9/7/51
Impeller type ..... Closed
Atm. temp. ..... 72° F.

Pump capacity (gal./min.)	0	112	148	159	177–186*	88–119**
Measured pressures						
Suction (ft.)	0	0	0	0	0	0
Leakage joint suction side (ft.)	97	87	63	54	16	0
Stuffing box (ft.)	119	102	69	43	18	—10
Volute-avg. (ft.)	232	210	172	139	72	22
Discharge (ft.)	288	272	226	188	113	29
Measured bearing temperatures						
Inboard (° F.)	>147	97–108	93–111	108	147–172	115–145
Outboard (° F.)	102	100	93–100	100	104–108	108
Calculated radial load at impeller (lb.)	307	178	78	44	?	?
Calculated bearing loads						
Inboard-radial (lb.)	697	402	177	100	?	?
Outboard-radial (lb.)	390	226	99	56	?	?
axial (lb.)	—440	—350	—215	—15	—81	+88
Calculated bearing life						
Inboard (yr.min.life)	1.1	5.9	69	383	?	?
Outboard (yr.min.life)	1.1	3.4	17.1	1034	?	?
Shaft deflection at impeller (in.)	0.0174	0.0101	0.0044	0.0025	?	?

* Pump starting to cavitate.
** Pump operating under severe cavitation conditions.

mains relatively normal over the entire range in capacities tested. These data indicate that the high shaft deflection present can twist the inner ring of the inboard bearing, create a stress of unknown magnitude in the bearing with attendant high-bearing temperatures, and finally effect a failure of the bearing. One half of the total deflection is calculated to come from the bending of the shaft between the bearings. It is the reason for the inboard bearing failures and is discussed in the Appendix under the subject "Deflection of the Shaft at the Inboard Bearing."

The shaft-deflection values are based on a calculated unbalanced radial load. At the end of the performance curve this load is calculated to be relatively low; however, the inboard bearing temperature is very high. This occurs where the pump is starting to cavitate and where cavitation is excessive. When the pump is cavitating, the impeller is irregularly filled with liquid and under these conditions unbalanced loads of unknown magnitude can be developed with the attendant fluctuation in shaft deflection to high and low values.

The bearing-temperature data indicate that this pump could be operated safely in the capacity range of 100 to 160 gal./min. The shaft-deflection calculations indicate that some trouble should be experienced with leakage at the packing gland because the shaft deflection is too high in the lower part of this capacity range.

After these experimental data were taken, orifices of the proper size were installed in the line to the shipping department and the line for circulation to the storage tank. The orifices restrict the flow from the pump and impose an additional head on the pump, sufficient to keep the pump operating on its performance curve.

This installation has been in operation since August 20, 1951, with a shaft and bearing failure on June 9, 1953, and on January 1, 1954, as compared with shaft and bearing failures about every three weeks after the pump was installed in April, 1950. The shaft failures are due to shaft deflection and the resultant excessive scoring of the shaft by the packing. This continues to be a problem and necessitates frequent repacking of the pump's stuffing box.

Acknowledgments

Acquisition of the material presented in this paper, especially on the performance of pumps, was made possible only through the full support and cooperation of the personnel in the maintenance shops, engineering groups, and operating units in the different plants of the Carbide and Carbon Chemicals Company. Valuable help was received from a number of pump manufacturers in providing drawings, data, and information on their pumps. Later the manuscript and the appendix were reviewed by these pump manufacturers and by some other large users and specifiers of pumps. Also, the ball-bearing discussions in it were reviewed by the engineering department of SKF Industries, Inc. The comments and suggestions of all concerned have assisted greatly in making this presentation possible. All this help is gratefully acknowledged.

Notations

a = overhang or distance between centerlines of impeller and inboard bearing, in.

b,c = distance between centerline of impeller and a change in cross-section of shaft, in.

B_2 = over-all width of impeller at periphery, in.

d (with subscript) = diameter of shaft at cross-section as indicated by subscript, in.

D_2 = diameter of impeller, in.

E = modulus of elasticity for shaft material, value used in all calculations is 3×10^7 lb./sq.in.

g = acceleration due to gravity, 386 in./(sec.)/(sec.)

h = total head developed by pump, ft.

h (with subscript) = head at point indicated by subscript, ft.

H (with subscript) = head at point indicated by subscript plus suction head, ft.

I (with subscript) = moment of inertia for shaft at cross-section as indicated by subscript, $(in.)^4$

K = hydraulic radial load constant

l = distance between centerlines of inboard and outboard bearings, in.

L = distance between centerlines of outboard bearing and impeller, in.

n_c = critical speed of pump shaft, rev./min.

r = impeller radius, in.

R_1 = radial load on outboard bearing, lb.

R_2 = radial load on inboard bearing, lb.

s = distance between impeller shroud and casing wall, in.

$s - t$ = clearance between back vanes and casing wall, in.

S = specific gravity of liquid

t = height of vanes on back of impeller, in.

T = net unbalanced axial load, lb.

T (with subscript) = axial load, lb., direction indicated by subscript

W = net or total unbalanced radial load at impeller, lb.

W_i = weight of impeller, lb.

W_r = hydraulic radial load at impeller, lb.

y_i = deflection of shaft, in., due to weight of impeller

Y_{max} = maximum static shaft deflection at centerline of impeller, in.

SUBSCRIPTS

a,b,c,l,x — refers to section of shaft where diameter or moment of inertia is under consideration.

s — refers to suction side of pump or shaft as case may be.

st — refers to stuffing-box side of pump.

$s - st$ — refers to shaft or impeller hub on stuffing-box side of pump.

w — refers to wearing rings of pump and impeller.

$w - s$ — refers to wearing ring on suction side of pump.

$w - st$ — refers to wearing ring on stuffing-box side of pump.

v — refers to volute in pump casing.

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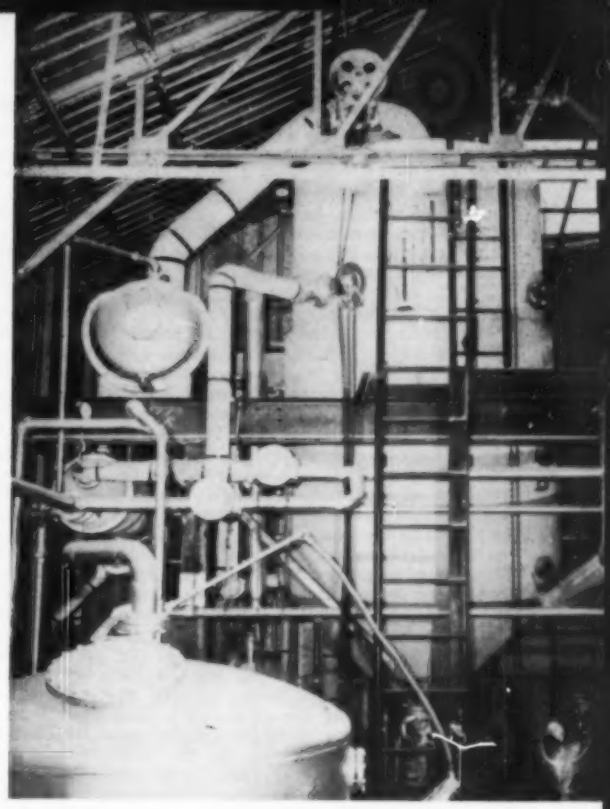
* Literature Cited in Appendix only.



Portion of the plant at Monticello, showing cooker and its accessories.

A PROCESS FOR DEHYDRATING AND DEFATTING TISSUES AT LOW TEMPERATURE

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R. K. Finn, University of Illinois, Urbana, Illinois

Solvent extraction, widely used in defatting relatively dry substances, is historically a recent phenomenon. Pressing oil from tissues is one of man's early applications of engineering. Yet solvent extraction has made such advancement because of uniformity and quality of products and economy of production that it has replaced pressing methods in many instances.

The expansion of solvent extraction to the defatting of water-wet substances is a new development which is likely to find wide application in the processing of foods and pharmaceuticals. Conventional methods of cooking followed by pressing may well be replaced by new applications of the principles of entrainment of water by solvents.

When the objective is purely dehydration, the steam costs are higher than conventional drum drying and spray drying. However, when it is desired to dehydrate to preserve enzymes or other heat-sensitive values, then dehydration at low temperatures by the use of an entrainer is far less expensive than freeze-drying with which this process would compete. When the objective is defatting in addition to dehydrating, as it would be, for example, in the processing of fish or offal, the process is at least no more expensive than conventional rendering. An important advantage is that the products possess better stability and more of their protein is biologically available. Moreover, offensive odor and water pollution are completely absent when the azeotropic process is used.

All operations are simple. One need only visualize any modern solvent extraction plant–batch or continuous–in operation. In the azeotropic method a dehydrating step precedes the solvent extraction. Instead of the tissue being charged into the solvent extractor, as occurs with oil seed extraction, the ground, wet oily tissue is dehydrated before it is solvent extracted, with the use of the same solvent as is employed in extracting the fat. After the moisture has been removed, the tissue particle is treated in the same general manner as any oil seed. Care is taken to operate at temperatures and pressures that will not damage the tissue for the purposes desired. The same advantages that have been outlined for solvent extraction-stability and uniformity in both the oil and meal of seeds—obtain for the oil and meal of solvent-extracted wet fat tissues.

It should be noted that conventional methods for dehydrating wet fatty tissues involve high temperatures or long drying times. These are made necessary, as pointed out by Ritchell *et al.* (*4*) in their studies on air-drying of meat, because a coating of fat forms on the surfaces in such a manner that the escape of water vapor is impeded. Case hardening is encountered also at high temperatures; colloidal gels within the tissue shrink to form tough integuments which bind the water. When finally dried, the product is usually discolored and its nutritional value is impaired. Upon storage it tends to become rancid and unfit for food or pharmaceutical use. Commercial fish meal represents a typical fatty tissue which has become degraded by the leaching and scorching which accompany conventional wet-rendering processes. Dry rendering of fatty tissue constitutes an even harsher treatment.

Flow Sheet of the Process

For several years the VioBin Corporation at Monticello, Illinois, has used a batch process, as shown in Figure 1, to dehydrate a variety of plant and animal tissues. Wet tissue is ground up and then suspended in a water-immiscible fat solvent. Water is removed from the tissue by distilling off a constant-boiling mixture (heterogeneous azeotrope). Fat is simultaneously dissolved in the excess of suspending solvent and can be recovered separately. The basic flow sheet applies, for example, to the drying of meat with ethylene dichloride as entrainer. Other solvents can be used, and in fact the entire process can be made continuous (*2*). The present discussion however, will be limited to performance at the Monticello plant.

Ground or chopped meat is first slurried with about an equal volume of solvent at

room temperature. The mixture is then fed at constant rate into a steam-jacketed "cooker," which contains hot ethylene dichloride. Ostensibly there is only one liquid layer present, but water within the cellular structure of the tissue distills freely. As a result, the entire contents of the cooker assume the azeotropic temperature, which is 71° C. (160° F.) when using ethylene dichloride at atmospheric pressure.

The feeding of slurry into the cooker continues until a full charge has been admitted. The size of charge depends somewhat on the fat content of the meat, but a three to five-fold excess of solvent over raw tissue is generally desired. The solvent level in the cooker is maintained by a total reflux of solvent vapors. Water of course is drawn off separately by means of a decanter inserted in the solvent return line. As shown in the flow diagram, an external heater is provided so that superheated solvent vapors may be returned to the cooker; such an arrangement relieves the heat load on the cooker jacket and permits more rapid dehydration in large vessels.

During the drying fat passes through the cell walls of the tissue into hot solvent where it remains in solution. In fact, as water moves out of the cells and is distilled, the extraction of fat by solvent becomes increasingly effective. By the time water has been removed, practically all the fat has become dissociated from the tissue. It is in such form that one or two rinses with fresh solvent suffice to remove it completely from the meal.

Completion of drying within the cooker is heralded by a rather abrupt rise of the temperature to 83° C. (182° F.), the normal boiling point of ethylene dichloride. The entire contents of the cooker are then discharged by gravity into a desolventizer. This vessel is essentially a steam-jacketed, revolving, horizontal dryer, but it serves a dual purpose. When it is in the upright or receiving position (Figure 1), it has a "false bottom," which consists of an internal filter frame fitted with a filter cloth. Fat-rich solvent, or miscella, drains through this filter cloth and is pumped via a polishing filter to the fat kettle where it is distilled.

The granular meat solids remaining in the desolventizer are light gray in color and of low-bulk density. If a low-fat meal is desired, several displacement washes with solvent are necessary. Any wash liquors are recycled for use as make-up solvent in treating subsequent batches of raw tissue.

After draining off as much solvent as possible from the meal, steam is applied to the jacket of the desolventizer and residual solvent is removed. This is accomplished at a temperature below 100° C. and preferably with the aid of vacuum. Agitation is provided by rotating the desolventizer at 4 to 6 rev./min. To complete the desolventizing, a short blast of direct steam is used in the final stages, a step which is also carried out under reduced pressure in order to keep the temperature as low as possible. As shown on the flow diagram, the meat solids from two cooker batches can be desolventized in a single operation. The solids are finally discharged either pneumatically or by gravity through manhole openings in the desolventizer. A typical analysis of meat solids shows less than 1% fat and less than 2% moisture although the character of the process permits varying the residual quantities of moisture and fat in the final product. The residual solvent in the meal can be completely removed if desired.

Recovery of oil from the miscella follows closely the conventional methods used throughout the solvent-extraction industry. Vacuum distillation is combined with steam sparging to remove the last trace of solvent. Exact composition of the fat or oil will depend upon the solvent used and the temperature employed. As a rule, all oil-soluble vitamins and phospholipids are retained as well as any oil-soluble hormones. Refining procedures consist of the usual decolorizing with char or fuller's earth and deodorizing with steam under high vacuum.

In addition to the major items of equipment shown in Figure 1, a storage tank for solvent and also scrubbing devices for recovering solvent from waste air and water are provided. For example, it can be noted that all vent lines pass to a vent condenser. This in turn exhausts to atmosphere through a bed of activated charcoal, which is occasionally steamed out to recover valuable solvent. Likewise, water leaving the decanter and steam leaving the jet ejectors pass through a water scrubber where low-pressure sparge steam is added. Water from the scrubber is discharged to the sewer, but solvent-rich steam is returned to the vent condenser. These provisions for solvent recovery have kept solvent losses well below 1% of the weight of raw tissue.

Biochemical Engineering Aspects

Several features of the process just outlined deserve further comment. One of these is that the solids do not contain an excessive amount of fines. A dust filter is installed in the vapor line from the desolventizer, but the problem is not nearly so severe as in most solvent-extraction processes where high temperatures have been used. The temperature used in azeotropic drying is sufficient to cause coagulation of the protein but it is not so high as to cause crisping or browning. If held much above 100° C. for any period of time, proteins become toasted and brittle so that they fragment easily. Such solids are difficult to filter and to desolventize.

To avoid sticking on the sides of the vessel and to avoid agglomerate formation, the ground tissue is precoagulated at a temperature above 60° C. but below 100° C. This step is usually carried out in the presence of solvent, and the mixture is stirred to keep the solids in separated form. Treatment is continued until albuminous material contained in the raw tissue is at least partially coagulated. Then the slurry is fed to the cooker in the usual manner.

It is also possible to introduce a slurry made up of ground tisue in cold solvent, provided it is added slowly onto the surface of the boiling solvent so as to bring about "flash" dehydration. This eliminates the precoagulation step.

CHOICE OF OPERATING TEMPERATURES

The temperature of drying may be altered either by changing the solvent or by adjusting the pressure. Selection of an appropriate temperature depends upon the use and properties desired of the final product. For those unfamiliar with the effects of temperature on proteins it may be well to explain briefly that few of them will stand temperatures above 60° C. for any length of time without undergoing some form of denaturation. This denaturation coagulates the protein and inactivates the enzymes as a rule, but does not damage the nutritional value of the proteins or vitamins. In the production of pancreatin or raw liver powder, temperatures below 60° C. are used because the proteins must be recovered without heat coagulation. The engineer must be fully aware of the peculiar properties of each material he is handling. Often there are sharply defined critical temperatures which must not be exceeded. Enzymes are especially heat sensitive and may be appreciably inactivated at temperatures as low as 30° C. Certainly in the range 50 to 60° C. a majority of them are unstable. Low pressure (50-250 mm.) is commonly used during azeotropic removal of water whenever low temperatures are necessary.

On the other hand, fish meal and meat meal are examples of azeotroping at atmospheric pressure. Even for these the temperature is always below 100° C., which insures no damage to the food values contained in the protein.

Table 1.—Physical Properties of Typical Solvents Used for Water Removal

Chemical formula	Ethylene dichloride CH_2ClCH_2Cl	Trichlor-ethylene $CHCl=CCl_2$	Perchlor-ethylene $CCl_2=CCl_2$	Chloro benzene C_6H_5Cl	Benzene C_6H_6	n-Heptane C_7H_{16}
Mole. wt.	99.0	131.4	165.8	112.6	78.1	100.2
Sp. Gr. 20° C.	1.253	1.464	1.623	1.107	0.879	0.684
Solubility in water 25° C., g./100g.	0.84	0.11	0.015	0.049	0.07	Insol.
Normal b.p., ° C.	83.5	86.9	121.2	132.1	80.1	98.4
Azeotropic distn. point at 1 atm., ° C.	71.4	73.2	87.7	90.7	69	79.5
Solvent: water ratio by wt.	11.3:1	13.4:1	5.3:1	2.5:1	10.0:1	6.7:1
Latent heat at b.p., cal./g.	77.3	57.2	50.0	77.6	94.1	76.5

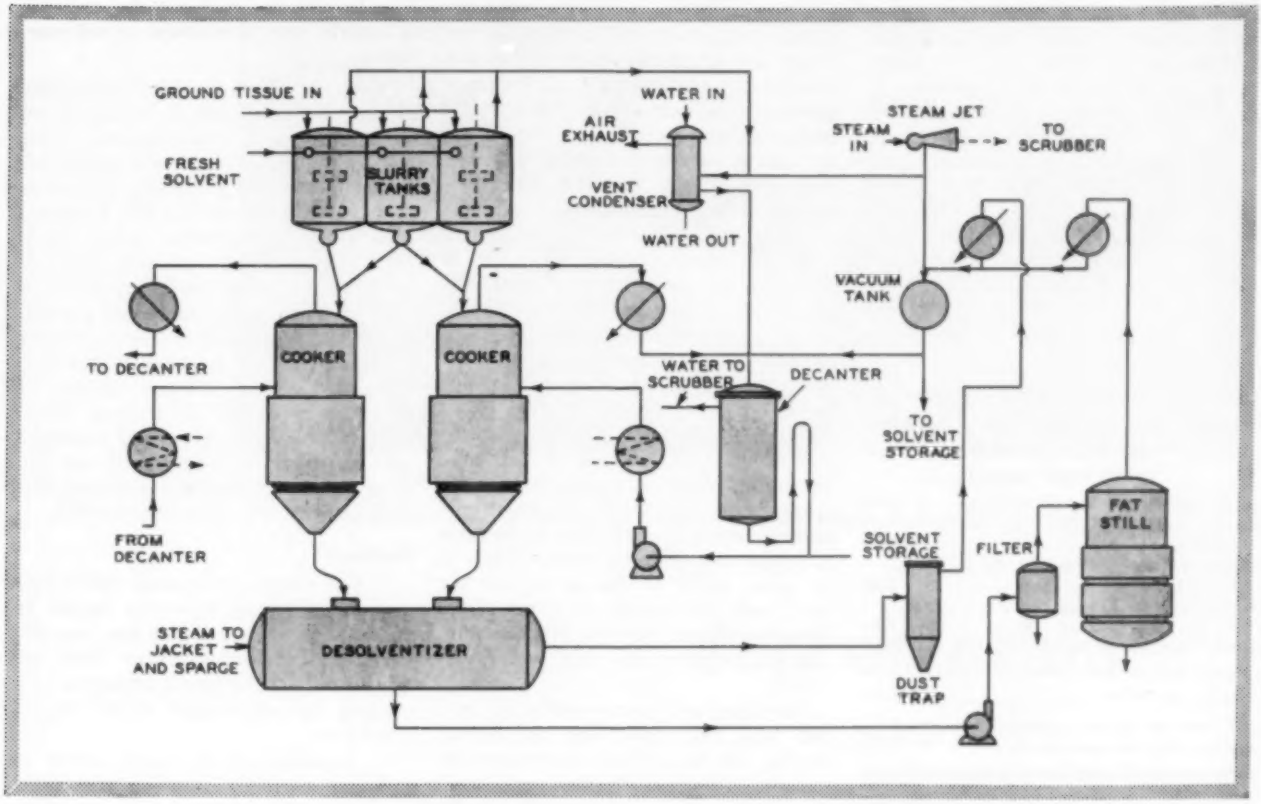

Fig. 1. Azeotropic drying and defatting as carried out at the VioBin plant.

CHOICE OF AN AZEOTROPING AGENT

A variety of organic solvents is suitable for use as entrainers. The only requirement is that such solvents be substantially immiscible with water and that the azeotropic distillation temperature be low enough at the pressure employed. For enzyme preparations and for raw tissue powders the maximum allowable temperature is usually 40° C. The weight ratio of solvent to water in the azeotropic mixture should be low, because if too much solvent must be used, the cost of heating and revaporizing it becomes prohibitive. Fortunately, the low latent heats of organic solvents as compared to water make it economically feasible to evaporate the larger relative quantities of solvent in order to remove moisture from the tissue. Pertinent physical properties of several azeotrope-formers are listed in Table 1. Many other solvents could also be used.

Besides the purely economic considerations such as low cost and commercial availability, other properties of an entrainer must be taken into account. These include ease of separation from the dried meal, toxicity, flammability, and corrosiveness. Chlorinated hydrocarbons are favored often because they are nonhazardous and many are nonflammable. Furthermore, these solvents, particularly ethylene dichloride or trichloroethylene, dissolve a variety of lipoid substances including the glycerides, sterols, phosphatides, and oil-soluble vitamins, but they do not vitiate the enzymes or alter the biological value of the proteins. Heptane is in many ways a superior solvent. It has a favorable azeotrope ratio, but is of course highly flammable.

DRYING OF LIQUIDS

A variety of animal and vegetable tissues has been dried satisfactorily in the pilot-plant or factory of the VioBin Corporation, but liquid extracts and colloidal fluids such as blood, milk, serum, and egg can be dried also. Such aqueous fluids are concentrated usually in conventional evaporating equipment to between 30 and 50% solids before drying.

Operating difficulties arise with liquids which contain no inherent cellular structure. Stick water, or fish solubles, which is a by-product of fish rendering, forms a gummy deposit on the walls of the cooker if dried in the usual manner. A similar coating of the vessel is noted in the drying and defatting of blood and milk. Liquids of this character must be injected either in atomized form or else as fine jets directly into or above the boiling solvent so that the natural agitation of boiling breaks the jets into fine droplets. It is usually advantageous to emulsify the liquid with a small portion of cold solvent prior to the spraying. As soon as the emulsion contacts the boiling solvent it is broken, and the resulting solids are of more uniform size than when unemulsified liquids are sprayed or injected. A similar emulsification technique can be used for drying soft, glandular tissues, which are first pulped or homogenized into a semiliquid state. These materials can be added dropwise rather than by spraying if the temperature is above 60° C. because they coagulate rapidly upon contact with hot vapor or liquid.

When modified for handling heat-sensitive liquids, the dehydration process may be referred to as azeotropic spray drying. Short contact times are combined with low operating temperatures, and as a result the product is completely free from denaturation.

Economic Considerations

The size of equipment used in azeo-

tropic dehydration is not excessive even for the batch process. Two 2,400-gal. cookers can dry 20 tons of raw tissue (65% water) in a 24-hr. period. A single desolventizer 6 ft. in diam. and 14 ft. long is adequate for such a plant. The total cost of all equipment to install would be about $100,000. This figure includes the cost of solvent but does not include the cost of a building. The daily operating costs summarized in Table 2 are based on actual operation of the plant at Monticello, Illinois, with the use of cost bases given in the literature (*1*).

Table 2.—Daily Operating Costs * for Processing 20 tons/24-hr. day of raw material (65% tissue water)

Labor: 48 man-hr./day @ $1.50/hr.	$ 72.00
Steam: 144,000 lb./day @ $0.70/1,000 lb.	100.80
Water: 270,000 gal./day at 70° F. @ $0.02/1,000 gal.	5.40
Power: 320 kw.-hr./day @ $0.01/kw.-hr.	3.20
Solvent Loss: 280 lb./day @ $0.11/lb.	30.80
Total cost per 24-hr. day	$212.20
Unit cost/100 lb. raw	$0.5305

* Does not include overhead, interest on investment, maintenance repairs, etc.

There is no doubt that when one considers dehydration alone, azeotropic defatting and dehydrating are more expensive than simple drying by severer methods. With ethylene dichloride, which has an azeotrope ratio of 11.3 lb. of solvent/lb. of water, somewhere between 4 and 5 lb. of steam are required to evaporate 1 lb. of water from wet tissue and to recover all solvent. On the other hand, when it is recognized that defatting is accomplished in addition to dehydration, the cost picture is not so unfavorable. In fact, with heptane as a solvent the azeotropic process holds an economic advantage over wet rendering. For example, with fish the following costs must be totalled when considering the conventional process: steam cooking of fish, mechanical pressing, drying of the press cake, filtering and centrifuging of large amounts of press water, and finally evaporating the press water to 50% solids before marketing.

Potentialities of the Process

The widespread use of azeotropic dehydration for natural products will come as soon as the processor is aware of the superiority of the quality of the products as compared to similar products dried by conventional methods. Full appreciation of the value of labile biological substances is just beginning and the demand for undenatured products will certainly increase. Feed manufacturers, for example, are setting up standards to assure that the protein has high biologic value and digestibility as well as a full complement of growth and vitamin factors which are found naturally in the fish or meat. Present methods for the processing of meat scrap make it practically impossible to produce a uniform product with the protein, vitamin, and mineral values intact. Moreover, the meals are not stable, in contrast to those prepared by the azeotropic method.

At the present time fish meal is processed by pressing. The "stick" or press water either goes into the sea or is evaporated to make what is known as fish solubles. Excess heating has been shown to be responsible for fish meal of low biologic quality and poor digestibility. In fact, fish meals vary so widely that results with one type of meal may be entirely different from results with another type. In contrast, the azeotropic process makes a meal that is uniform in quality and perfectly stable. There is no press water to dispose of for the meal itself contains all the values of the press water; the new meal is a combination of ordinary fish meal with press water.

The azeotropic process makes not only fish meal and meat meal for animal feeding but also excellent products for human feeding. Fish flour and meat flour for human use are now being made. The United Nations Children's Emergency Fund is studying fish flour made by this process in feeding experiments in Ecuador and Mexico.

Pilot plant experiments reveal a possibility which may revolutionize the processing of milk. The milk is first evaporated by multiple-effect evaporators to produce a highly concentrated liquid which is then processed by the azeotropic method. The milk is thereby separated into defatted milk powder and butter oil. Both these products are stable and of excellent quality. The defatted milk powder will reconstitute to fluid milk when water is added, and the butter oil can be used for butter production by modern methods. These studies are not complete, but enough has been done to predict the success of this development for producing milk solids for both animal feed and human food.

The possibilities in vegetable tissues have been partially evaluated and look promising. Cocoanut, with its high moisture content, can be processed in the raw state without preliminary drying; thus it provides a cocoanut oil of excellent stability and a meal of much higher biologic value than is now obtainable in the form of copra. It has been suggested also that the palm fruit, an excellent food and now completely destroyed when palm oil is made, could be conserved by the use of the azeotropic method in the processing of palm oil.

Future expansion of the azeotropic method for processing wet fat tissues will be aided by the absence of offensive odors and the absence of by-products that would contribute to water pollution. The decentralization of population into suburban areas, and the increased use of distant areas for recreation are forcing the elimination of industries which contribute to air and water pollution.

These are only a few of the potentials of the azeotropic method. An indication of interest in this development is the fact that a group within the fishing industry in Norway is erecting a plant in cooperation with the VioBin Corporation, which will process whale meat, fish livers, and other products. The 10-ton plant now being built is designed to process products profitably and yet will be used also for study and evaluation by the varied fishing interests of Norway. Another plant, of 100-ton capacity, is under construction at Salinas Cruz, Mexico, where raw fish will be converted into fish meal for animal feed and fish flour for human use. It is expected that both plants will be operating in 1955.

Summary

A new process for simultaneously drying and defatting biological tissues or fluids at low temperatures has been described. Previous accounts have appeared only in the patent literature (*5*). Among the advantages which can be cited are:

1. Retention of biological values in original material, including all water-soluble proteins or peptones.
2. Separate recovery of oily constituents and stable, dry solids.
3. Production of solids in a granular form, free from excessive dust.
4. Complete freedom from obnoxious odors. The water which is removed can be disposed of without polluting streams or lakes.
5. Minimum exposure to air or oxidizing conditions.

Though some of the substances which may advantageously be dried by the azeotropic process can also be dried by conventional spray drying, others cannot, at least without destruction of valuable constituents. Finally, the azeotropic defatting can be used for certain materials from which values cannot be recovered by any other known process.

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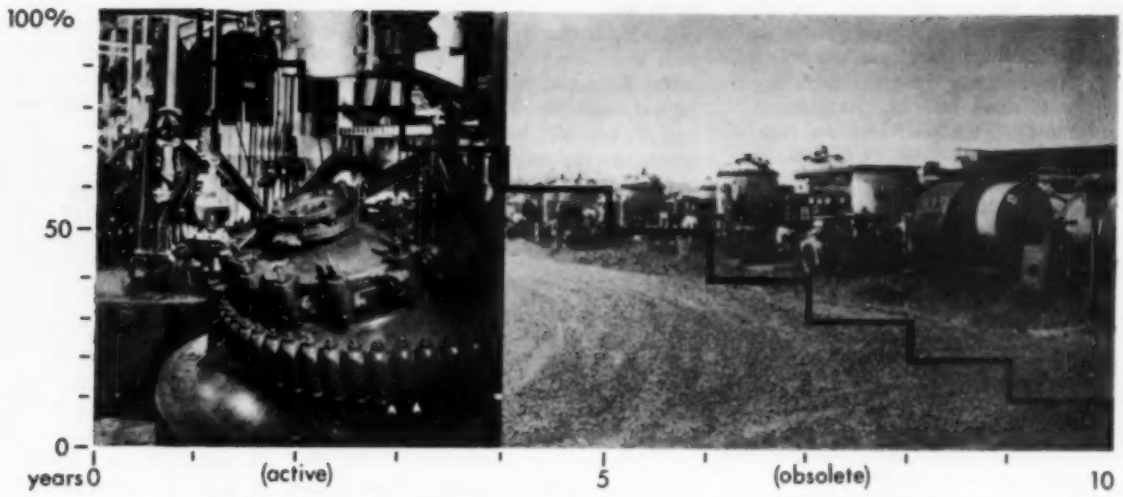

Rapid obsolescence of chemical equipment requires modernization of depreciation policies.

depreciation AND amortization

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Chemical engineers must understand the basic concepts of depreciation before attempting "free thinking" on complex business problems where ideas on depreciation may be modified or neglected in order to get a realistic answer to a practical problem. There are many reasons why depreciation is particularly important to chemical engineers and the chemical industry. Paramount among these is the fact that high investment is a characteristic of the chemical industry, that is, the investment required per worker is higher than in most other industries such as textiles, leather, food products, steel, and tobacco. In addition, the investment in the chemical industry is increasing with the rising trend towards use of automatic controls in place of operators. Accordingly, clear thinking is necessary in solving the problems of depreciation, which constitutes a large portion of the costs of chemical manufacture.

In estimating the operating costs of manufacturing a new chemical, it may be found that depreciation will be a more important cost item than operating labor. For example, it is frequently the case in a plant which is largely automatically controlled, that one operator turning out continuously large volumes of a product may handle a million dollars worth of plant facilities. In such a case, the annual depreciation may be $50,000 to $100,000, whereas the bare cost of operating labor based on one man per shift would be only about $25,000.

Logical thinking also is a necessary prologue to a study on depreciation in relation to the use of installed facilities. First, the depreciation rate should be realistically determined. Second, one should not be misled in considering the cost of utilizing investment that has been completely depreciated. The accountant may not include depreciation as an item of cost for investment that has been completely depreciated, how-

ever the use of such cost excluding depreciation may be unwise in determining selling-price structures and policies. A more conservative practice is to include a normal rate of depreciation in any selling price consideration regardless of the extent to which the facilities have been depreciated.

Depreciation is of vital importance too in considering the abandonment of worn-out or obsolete facilities. If the facilities have been completely depreciated for income tax purposes, then abandonment will not involve a tax penalty. On the other hand, if the assets have not been completely depreciated, it may not be possible taxwise to charge the undepreciated portion of the assets to cost, thereby necessitating a higher tax.

Again depreciation takes on added importance in a depressed market. It constitutes a fixed charge that does not vary with the quantity of product made and sold. As a result, break-even points, where selling price covers only the cost of manufacture, may be encountered at relatively high levels of operation, possibly as high as 75% of plant capacity. This indicates the need to keep such plants operating at high rates in order to return a profit.

Basically, depreciation or amortization attempts to anticipate lack of usefulness of permanent investment or capital assets. For example, if a converter is purchased at a cost of $100,000 and it is believed to have a useful life of 10 years, then $10,000 a year is withheld from profits and allocated to cost annually. If the converter subsequently falls apart or becomes obsolete at the end of 10 years and has no salvage value, then its lack of usefulness was correctly anticipated and the depreciation policy was sound. This annual withholding or setting aside from profits of a portion of the cost of the converter, or any other capital asset, is accounting recognition that one of the costs of doing business each year is an allocated portion of the capital assets. This allocated portion of the cost of capital assets is depreciation or amortization. It is an interesting observation that the effects of acquisition of capital assets on the total profits of any business cannot be determined until the business has been terminated. This observation may seem surprising because the costs of all capital assets are known. However, variables that cannot be predicted accurately until time of termination are salvage value and the income tax rate. Variations in the income tax rate over the years of operation of the business will affect the extent to which depreciation allowance will reduce the tax to be paid and hence change the profits.

Definitions

Amortization is usually associated with a definite period of distribution of costs. Examples are found in (1) leasing of land for a period such as 10 years and (2) Necessity Certificates, where 5-year amortization is allowed by the Government for facilities constructed at least partly for national emergency. Depreciation, on the other hand, usually deals with an unknown or estimated period over which the costs of assets are distributed. It is true, however, that the terms are loosely and interchangeably used and the foregoing differences are not always clear cut.

Depreciation is defined concisely by the Bureau of Internal Revenue Code as "A reasonable allowance for the exhaustion, wear and tear of property used in the trade or business, including a reasonable allowance for obsolescence." This definition is based on the orthodox accounting concept of depreciation, which is defined by the American Institute of Accountants as "Depreciation accounting is a system of accounting which aims to distribute the costs or other basic values of tangible capital assets, less salvage (if any), over the estimated useful life of the unit (which may be a group of assets) in a systematic and rational manner. It is a process of allocation, not of valuation. Depreciation for the year is the portion of the total charge under such a system that is allocated to the year. Although the allocation may properly take into account occurrences during the year, it is not intended to be a measurement of the effect of all such occurrences." The principal point to be noted about the orthodox accounting concept of depreciation is that the cost of the asset to be allocated to the annual expense of the business is the original cost of the asset and not the current value.

The orthodox accounting treatment of depreciation may be likened to the simpler and more easily understood accounting treatment of prepaid insurance. Insurance is commonly purchased for a 3-year period and the 3-year premium payment is allocated to the annual expenses of doing business over the 3-year life of the policy. If the lump-sum premium payment were charged to expense in the one year, it would distort the year's cost or expense of operating the business. Comparison of profits between that year and the following two years would not be realistic unless an adjustment were made for the 3-year premium payment in the first year. To avoid such adjustments, which could become infinite with the almost endless types of business expenses, the accountant allocates the cost of the insurance over the life of a policy. In a similar manner, the cost of a capital asset is allocated over its life through the medium of depreciation.

It must be realized here that depreciation is not a decrease in value of capital assets, though that is the definition commonly found in dictionaries and, of course, commonly used outside the accounting field. Finally, depreciation is not allocation of an expense to be paid for in the future when the present capital assets are replaced. Rather is depreciation always allocation of an expense that has already been incurred.

Estimating Lives of Facilities

In determining the lives of facilities in the chemical industry, obsolescence generally is of more significance than physical deterioration. Accordingly, in order to determine depreciation rates in the soundest manner, top personnel in management, in sales, in manufacturing, in research, and in the accounting functions are best qualified to give their opinions of obsolescence. Their judgments require appropriate weighting in order to obtain the best answers when the estimated lives of facilities are reviewed, preferably annually. This reviewing is desirable because obsolescence changes rapidly in the chemical industry because of the technical, sales, and other factors. A sound policy in estimating lives of facilities will avoid write-offs of partially depreciated or amortized facilities that may heavily distort costs in the year of write-off. Obsolescence may be classed generally in four categories, namely process, engineering, capacity, and product obsolescence. Process or chemical obsolescence is exemplified by replacement of the chlorhydrin process for ethylene glycol manufacture by the ethylene oxidation process. Engineering or mechanical obsolescence is typified by

the use or trend towards automatic controls in place of manual controls for processes. Capacity obsolescence generally refers to expansion wherein larger units replace smaller units originally used. An example of this type is the trend towards large air liquefaction units having hundreds-of-tons-a-day capacity in place of the much smaller units previously used. Product obsolescence is self-explanatory and is exemplified by the replacement of cellulose nitrate in the plastics industry by other newer plastics.

Depreciation Rates

The next step after estimating lives of facilities is to set annual depreciation rates which involve principally the selection of a method for setting rates. The most familiar method is the common straight-line method, but the declining balance method also has been used and, with the new 1954 tax law recently enacted, the sum-of-the-years-digits method may become more widespread. After the method has been selected for setting rates, it remains to determine whether rates will be set on individual items of equipment, or on composite groups of facilities, or even by the complete plant. The use of individual rates by items necessitates keeping detailed records of depreciation and does not permit averaging errors in judgment on individual items. The setting of rates for a complete plant is satisfactory if the operations within the plant have similar lives but an over-all plant rate does not permit selectivity by processes. The most logical grouping of equipment for a rate appears to be by processes.

Rate-Setting Methods

There are four commonly recognized methods for setting depreciation rates.

First is the relatively familiar straight-line method used in the original example. By this method a $100,000 item or group of items that are estimated to have a 10-year life would be assigned an annual depreciation of $10,000, or a rate of 10%.

The unit of production or use method is not commonly employed in the chemical industry. Rather it is used where physical depletion is a controlling factor in the usefulness, such as in the case of natural resources like minerals and timber. By this method, for example, assets valued at $100,000 and estimated to produce 100 million units would be assigned a depreciation rate of 0.1 cent a unit.

The declining balance method is used to give rates that are higher in the initial years than by the straight-line method. As a corollary, rates in later years fall below the rates by the straight-line method. The initial year's rate may be varied considerably. In the recently enacted new 1954 tax law, a rate of 200% of that of the straight-line method in the first year is permissible. Accordingly, in the tax law this rate is commonly referred to as the "200% declining balance method." Table 2 shows a comparison of depreciation by the straight-line method and by the 200% declining balance method for a distillation unit having an installed cost of $100,000 and an estimated useful life of 20 years with no salvage value. Note that by the straight-

(Continued on next page)

economics

Table 1 shows an example of process rates for a plant producing ethylene glycol by (1) cracking of propane to make ethylene and (2) oxidation of ethylene to glycol. There are two distinct process steps involved. With the assumption that the over-all plant is judged to have a useful life of 10 years, then the over-all plant depreciation rate will be 10%. However, by an examination of the separate process steps it may be concluded that the propane cracking step is subject to replacement by purchase of ethylene from a nearby petroleum refinery in 5 years. Thus, a process rate of 20% will be assigned to ethylene, and 10% to glycol. In 5 years the plant rate sets aside $5,000,000 reserve, which is reduced to $3,000,000 by write-off of the obsolescent $2,000,000 ethylene unit. The process rates set aside $2,000,000 for ethylene (which after write-off becomes zero) and $4,000,000 for glycol. After 10 years the plant rate has set aside only $7,000,000 or 87.5% of the plant cost, whereas the process rates have set aside 100%. The process rates permit selectivity where (1) the obsolescence factor differs between processes, as is usually the case, and (2) the rate of replacement differs. Rate of replacement may be an important factor, and the over-all rate must be set to take account of expected rates of replacement.

Table 1.—Example of Process vs. Plant Composite Depreciation Rates

Assumption A

Plant consisting of

1. Ethylene unit—$2,000,000 (propane cracking)
2. Ethylene glycol unit—$8,000,000

Assumption B

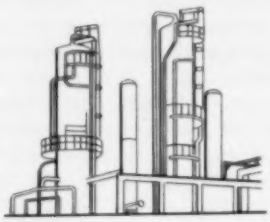
	Depreciation Rates	
	Plant rate	Process rate
Ethylene	....	20%
Glycol	....	10%
Total plant	10%	(12%)

	Depreciation Reserve		
		Process rate	
Years of life	Plant rate	Ethylene	Glycol
5 Years			
Depreciation set aside	$5,000,000	$2,000,000	$4,000,000
Ethylene write-off (replaced by purchase)	(2,000,000)	(2,000,000)	.....
Reserve	3,000,000	.....	4,000,000
10 Years			
Reserve	7,000,000	.....	8,000,000
% of plant	87½%		100%

Table 2.—Straight-Line Method vs. 200% Declining-Balance Method

Distillation Unit

Installed cost—$100,000
Estimated useful life—20 years



Depreciation

Years of life	Straight-line Method: Annual set-aside	Straight-line Method: Accumulated depreciation	200% Declining-Balance Method: Annual set-aside	200% Declining-Balance Method: Accumulated depreciation
1	$5,000	$ 5,000	$10,000	$10,000
2	5,000	10,000	9,000	19,000
3	5,000	15,000	8,100	27,100
4	5,000	20,000	7,290	34,390
5	5,000	25,000	6,561	40,951
6	5,000	30,000	5,905	46,856
7	5,000	35,000	5,314	52,170
8	5,000	40,000	→ 4,783	56,953
10	5,000	50,000	3,874	65,132
20	5,000	100,000	1,351	87,843

line method the annual set-aside for depreciation is $5,000. By the 200% declining balance method, $10,000 is set aside the first year and in the second year the set-aside is 10% of the remaining undepreciated balance of $90,000, or a set-aside of $9,000, and the set-asides are determined in a similar manner for successive years. Note also that the annual set-aside is higher by the declining balance method through the seventh year, but after the seventh year it falls below the $5,000 by the straight-line method and in the eighth year is $4,783. Finally, note that at the end of 20 years the declining balance method does not completely depreciate the distillation unit and about 12% of the initial installed cost remains undepreciated. However, two practical advantages of the declining balance method are that (1) depreciation is high in the initial years when maintenance costs usually are low and the reverse is true in later years of life, and (2) the declining balance method recovers a larger portion of the cost of the facilities in the early years when profits should be highest, thereby decreasing the risk in later years.

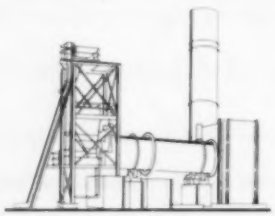
Finally, there is the sum-of-the-years-digits method included in the new tax law. This method has the same advantages as the declining balance method in the initial years because initial rates are high. In addition, it has the advantage over the declining balance method that the initial cost of the facilities can be 100% depreciated at the end of their useful life. Table 3 shows a comparison of depreciation by the straight-line method with the sum-of-the-year-digits method for a rotary dryer, the installed cost of which is $100,000 and estimated useful life 10 years with no salvage value. In this method the digits from 1 to 10, representing each of the years of useful life, are added, and, in this case the total is 55. In the first year then depreciation is taken at 10/55 of the total installed cost of $100,000, giving $18,182. In the second year 9/55 of the initial cost are taken and so on for the life of the facilities. Note that by the straight-line method the annual set-aside is $10,000. By the sum-of-the-years-digits method the set-aside in the first year is approximately $18,000, which is slightly below $20,000 by the 200% declining balance method in the first year. After the fifth year the sum-of-the-years-digits method results in annual set-asides lower than by the straight-line method, and in the sixth year the set-aside is $9,091.

In all methods, the over-all depreciation of facilities must allow for salvage value, if any. However, most chemical equipment, and certainly any special equipment, has low salvage values. The foregoing examples have been simplified on the assumption of no salvage value.

Table 3.—Straight-Line Method vs. Sum-of-the-Years-Digits Method

Rotary Dryer Installation

Installed cost—$100,000
Estimated useful life—10 years



Depreciation

Years of life	Straight-line Method: Annual set-aside	Straight-line Method: Accumulated depreciation	Sum-of-the-years-digits Method: Annual set-aside	Sum-of-the-years-digits Method: Accumulated depreciation
1	$10,000	$ 10,000	$18,182	$ 18,182
2	10,000	20,000	16,364	34,546
3	10,000	30,000	14,545	49,091
4	10,000	40,000	12,727	61,818
5	10,000	50,000	10,909	72,727
6	10,000	60,000	→ 9,091	81,818
7	10,000	70,000	7,273	89,091
8	10,000	80,000	5,454	94,545
9	10,000	90,000	3,636	98,181
10	10,000	100,000	1,819	100,000

Depreciation and Public Policy

Depreciation has an important bearing in relation to Government policy affecting manufacturers in many matters, such as income taxes—federal and state. Depreciation, always a factor in price controls, is a significant item in setting prices under Government contracts based on costs and, accordingly, is an item in determining renegotiation liability. Depreciation is important in the regulation of security markets where the viewpoint of the Government towards depreciation may be quite different from its viewpoint in tax matters. Depreciation also may play a part in deciding general property taxes. In some assessments depreciation is not recognized, but many assessors recognize depreciation by annual reduction in assessed valuation.

Previous Tax Law

In a study of depreciation in relation to income tax laws, the law that applied until the new 1954 law still applies in principle to all assets acquired before January 1, 1954 and to used assets acquired following this date. Under the

previous law the straight-line method was generally recognized and exceptions to the use of this method must be validated by the taxpayer. However, the declining balance method was recognized, although its use was limited to 150% of the straight-line method in the initial year. This limitation, of course, reduced considerably the attractiveness of using the declining balance method. In order to provide some uniform basis for administering the tax law and determining rates by the straight-line method, the Bureau of Internal Revenue has published a comprehensive list of estimated lives of facilities for all industries and of all types of equipment. In the case of the chemical industry about a dozen divisions are specified, including acids, alkalis, coal-tar products, electrochemicals, and pharmaceuticals, as examples. The estimated lives of over-all groups of facilities in these industries are from 15 to 20 years. These industry lives represent averages of all the equipment items which vary from 2 years for stoneware equipment to 50 years for platinum catalysts.

New 1954 Tax Law

Preliminary examination indicates that the new 1954 tax law is considerably more liberal concerning depreciation. The provisions of the new law apply only to new facilities installed after January 1, 1954. The new law allows, of course, the use of the straight-line method and, in addition as previously mentioned, permits the use of the declining balance method with a rate up to 200% of the straight-line method in the first year. It also includes the sum-of-the-years-digits method and any other methods that are no more liberal during the initial two-thirds of the life of the equipment than is the declining balance method. The declining balance method at 200% accumulates about 80% depreciation reserve during the initial two-thirds life of the equipment. Generally speaking, the new law is regarded as encouraging to new investment since it permits faster recovery of capital.

In addition, it puts the burden of proof on the Government rather than on the taxpayer as in the previous law. It permits the taxpayer to select the method for calculating depreciation. A taxpayer may select any permissible method, including a method other than the straight-line method, and later, if he desires, change to the straight-line method. The new law must be applied to complete depreciation accounts in order to take advantage of its more liberal provisions. Accordingly, over-all plant or similar broad accounts may be disadvantageous in applying the new law.

It is of interest to note also that the new tax law clearly permits optional treatment of research costs allowing the charging of research expenses to current expense annually. This permission has not expressly been granted heretofore. Alternatively, research costs can be capitalized and written off over a period of 5 years or longer. There are two limitations to the "expensing" of research costs. The taxpayer must elect to expense research costs in the first taxable year after December 31, 1953. In addition, such election must be adhered to unless consent is obtained from the Government to make a change.

Different Rates to Suit Needs

After one makes a study of the orthodox accounting treatment of depreciation and its tax aspects, it should be mentioned that no single depreciation rate will suit all uses—there is no such thing as a correct rate for all purposes. Usually the rates used for tax purposes will differ from those used for accounting purposes on the company books. This has been so when business judgment dictated use of high rates in the early years of the business in order to decrease the risk resulting from intense competition in later years. However, the more liberal provisions of the new tax law should narrow the gap between tax and book rates.

Necessity Certificates

In weighing this matter of depreciation one notes the item, "fast write-off" or amortization, permitted by Necessity Certificates. These fast write-offs have been widely characterized as a method of avoiding tax payments by large corporations. Of course, this is not true and the 5-year write-offs constitute merely a tax deferment. As a matter of fact, these fast write-offs are something of a gamble. They are advantageous at high tax rates, but if tax rates should rise following the 5-year write-off period the taxpayer will lose and not gain.

Replacement Cost Valuation

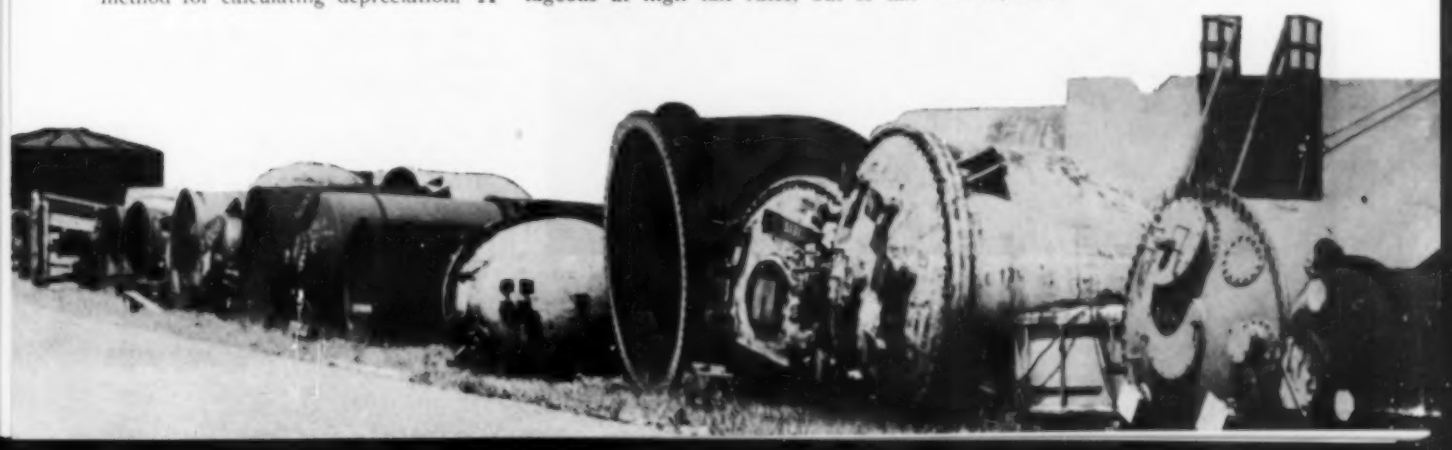
Another popular subject under depreciation is the use of replacement costs rather than original costs for valuation of facilities. The concept of replacement cost valuation has gained much favor in the recent decades of inflation and rising prices. However, human nature being what it is, it is quite likely that this concept would rapidly lose favor in a period of deflation and declining prices. In the chemical industry technological advances come so rapidly that replacement cost frequently may be lower than the original cost despite inflation. Good examples of this situation may be found in the manufacture of ammonia and methanol, where plants for manufacture of these products from natural gas can be constructed more cheaply at today's high construction costs than plants built 25 or 30 years ago for manufacture from coal.

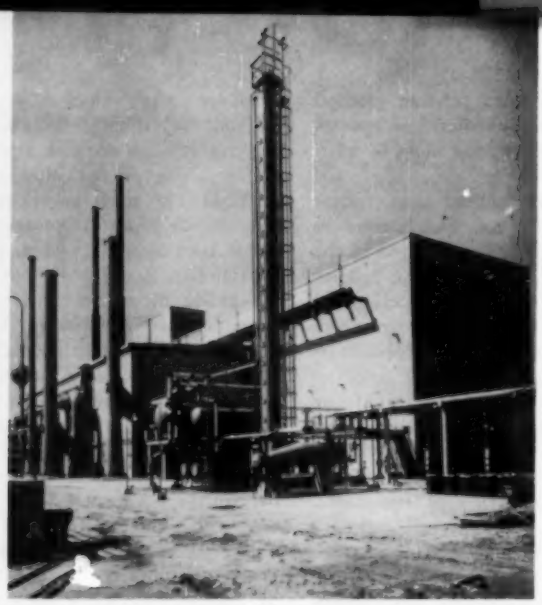
economics

Investment Records

A sound depreciation policy must be supported by good accounting records on capital assets or permanent investment. These records, if kept properly, will not only furnish the depreciation information needed by accountants but also will serve as excellent reference sources for chemical engineers in their studies of improving equipment and plant processes. Good investment records will support depreciation rates for taxes, enable accurate determination of investment in use, and support claims for damage by fire and explosion. The chemical engineer will find it well worth while to take an interest in the investment records and depreciation policies of the accountants in his company.

Presented at New York Section meeting, October 13, 1954.





One of Ethyl's Fractionating Towers.

effect of length of liquid path on plate efficiency

M. F. Gautreaux and H. E. O'Connell | Ethyl Corporation, Baton Rouge, Louisiana

Design of bubble-cap fractionating towers has been based on the assumption that each plate is a theoretical one on which vapor and liquid are completely mixed with the result that the vapor and liquid effluents are in equilibrium. This is not a true representation of the condition on a tray. Liquid enters the tray and receives successive contacts with vapor from the tray beneath. The action of the vapor on the liquid effects a highly agitated liquid, yet in spite of this high degree of agitation, there is not a complete mixing of the liquid; and thus, in most cases, the liquid leaving the tray is not in equilibrium with the bulk of the vapor.

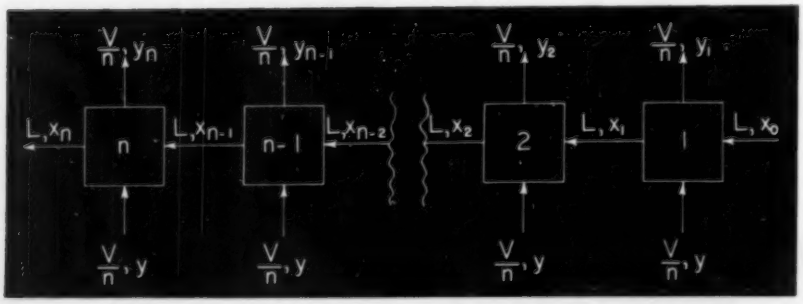


Figure 1. Schematic diagram of stages on a tray.

The complexity of tray operation and the fact that complete mixing of liquid is not obtained point to the question: Why is the theoretical plate concept used in the design of fractionating columns? The answer lies in the fact that the theoretical-plate concept lends itself to comparatively simple computation methods for the determination of the number of theoretical plates. This more than offsets the difficulty of relating the number of theoretical plates to the number of actual plates.

The relationship between the number of theoretical plates and the number of actual plates is called over-all column efficiency. The term plate efficiency, however, has several definitions. These are

Local Efficiency, E_p

This definition describes the approach to equilibrium at any point on the plate. In terms of vapor composition

$$E_p = \frac{y_t - y}{y_t^* - y} \qquad (1)$$

This local efficiency is related to the individual film resistance by Gerster, *et al.* (*5*):

$$\frac{1}{-\ln(1 - E_p)} = \frac{G}{Zk_Ga} + \frac{mG}{Zk_La} \qquad (2)$$

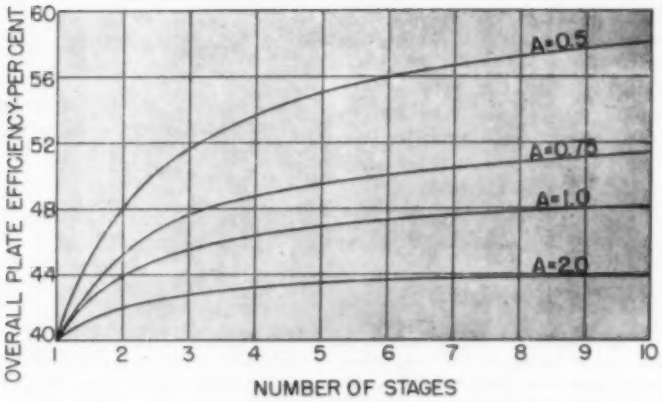


Figure 2. Effect of number of stages on over-all plate efficiency. Local efficiency = 40%

or, in terms of the number of transfer units,

$$\frac{1}{-\ln\,(1-E_p)} = \frac{1}{N_G} + \frac{mV/L}{N_L} \qquad (2A)$$

Over-all Plate Efficiency, E_o

This is the ratio of the actual change in the average vapor composition divided by the change that would occur if the vapor leaving were in equilibrium with the liquid leaving. In terms of vapor composition

$$E_o = \frac{y_{av} - y}{y_n^* - y} \qquad (3)$$

Over-all Column Efficiency, E

This is defined as the ratio of the number of theoretical plates required for the separation divided by the number of actual plates required.

It is desirable to have a correlation that predicts the number of actual plates from a calculation of the number of theoretical plates. There are several such correlations. One correlation (*10*) relates the over-all column efficiency to relative volatility and viscosity of the system. In most cases this correlation has given satisfactory over-all column efficiencies. One exception has been columns with a long liquid path. Under this condition the efficiency is greater than predicted by the previously mentioned correlation. The increase in efficiency results from the fact that there is a concentration gradient in the liquid as it flows across the plate.

The purpose of this paper is to present a correlation which will show the effect of liquid path. This paper is limited to the derivation of the relationship between the local efficiency and the over-all *plate* efficiency.

The presence of a concentration gradient in the liquid as it flows across the plate has long been recognized (*7, 8, 9, 15*) and there have been several investigations of the effect of this gradient on column performance. Kirschbaum (*8*) assumed that a plate consists of pools of liquid which are completely mixed. This is a good assumption, but unfortunately Kirschbaum's analysis is so complicated that it has found little application.

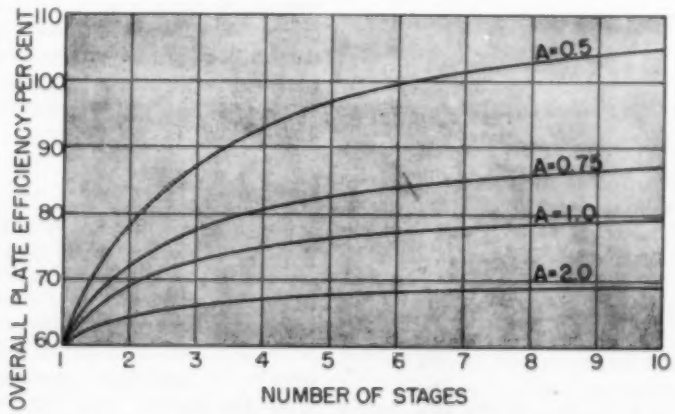


Figure 3. Effect of number of stages on over-all plate efficiency. Local efficiency = 60%

Lewis's Equations

Lewis (*9*) assumed that liquid flows across the plate unmixed. His equations have been widely used and are the basis for most of the analyses between local efficiency and over-all plate efficiency. Lewis derived equations for three cases.

Case I—Liquid flows across the plate unmixed, and the vapor enters the plate completely mixed.
Case II—Liquid is unmixed, the vapors rise from plate to plate without mixing, and liquid flows in the same direction on all plates.
Case III—Liquid is unmixed, the vapors rise from plate to plate without mixing, and liquid flows in opposite directions on alternate plates.

Case I has the widest application, and for this case, the relationship between the over-all plate efficiency, E_o, and the local efficiency, E_p, is as follows:

$$E_o = A(e^{E_p/A} - 1) \qquad (4)$$

where:

$A = L/mV$
L = liquid flow rate, moles/time
V = vapor flow rate, moles/time
m = slope of the equilibrium curve

Equation (4) is based upon the assumption that

1. Liquid flows across the plate unmixed.
2. Vapor enters the plate completely mixed.
3. L/V is constant.
4. Slope of equilibrium curve for conditions of plate is constant.
5. Local efficiency is constant across the plate.

The basic difficulty with Equation (4) is assumption (1), namely that liquid flows across the plate unmixed. Actually, there is considerable mixing and the degree of mixing is influenced by the length of the path. Because of this objection, it was felt desirable to present an analysis of the behavior of a plate that takes into account this mixing.

Proposed Equation

A concept is needed to permit a mathematical representation of the amount of mixing on a plate. One such concept would involve dividing the plate into stages, each stage consisting of completely mixed liquid. This is Kirschbaum's assumption that there are pools of liquid on the tray which are com-

pletely mixed. With this assumption and assumptions (2), (3), (4), and (5) listed above, the relationship between E_o, E_P, A and the number of stages n is

$$E_o = A\left[\left(1+\frac{E_P}{nA}\right)^n - 1\right] \qquad (5)$$

The derivation of this equation, shown in the Appendix, is based on the flow shown in Figure 1. Equation (5) is plotted in Figures 2, 3, and 4 where the point efficiencies are 0.4, 0.6, and 0.8 respectively.

A similar derivation was made by Sherwood and Pigford (*15*). Unfortunately their equation is in error, as noted in the errata to their book.

It is interesting to note that the limiting form of Equation (5) is Equation (4) as n approaches infinity. This follows since the equation of Lewis is based on the assumption of no liquid mixing which would by necessity give an infinite number of stages. Equation (5) has more application than Lewis's equation since it permits the analysis of a plate for the condition of no mixing to complete mixing of the liquid.

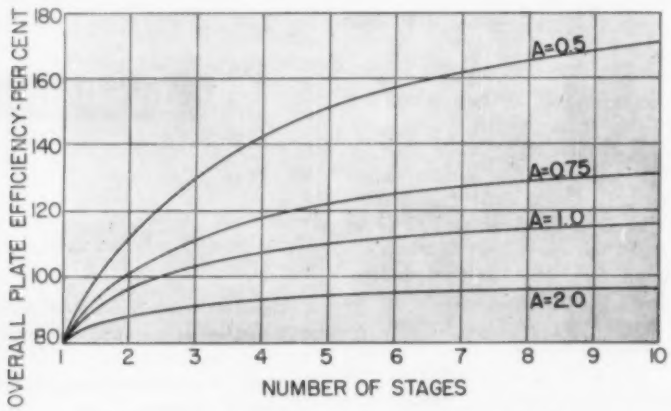


Figure 4. Effect of number of stages on over-all plate efficiency. Local efficiency = 80%

Discussion of Results

Figures 2, 3, and 4 are graphical representations of Equation (5). An analysis of these figures and of Equation (5) leads to the following conclusions:

1. The effect of the number of stages is more pronounced the higher the local efficiency, as shown below.

No. of Stages	A	E_P	E_o	$(E_o - E_P)/E_P$
3	1.0	40%	45%	13
3	1.0	80%	102%	28

However, in most columns the per cent increase in E_o over E_P will be approximately the same for a given number of stages irrespective of the value of E_P. This apparent anomaly results from the fact that E_P and A have an approximate relationship. As will be shown later in the section on Local Efficiency, the slope of the equilibrium curve is high usually when the local efficiency is low. For high local efficiencies, the converse is true.* Therefore, for E_P to equal 0.8, the slope of the equilibrium curve should be about 1.3, and this slope gives a value of A of about 0.8. On the other hand, for E_P to equal 0.4, the slope of the equilibrium curve ought to be about 5, and this slope gives a value of A of about 0.2. For the same number of stages the per cent increase of E_o over E_P would be approximately the same, as shown below.

No. of Stages	A	E_P	E_o	$(E_o - E_P)/E_P$
3	0.8	80%	171%	114
3	0.2	40%	73%	83

2. The effect of the number of stages is more pronounced in the first three stages and tends to level out with an increasing number of stages. This is shown below where values of E_o and n are listed for $E_P = 0.6$ and $A = 0.5$.

No. of Stages	E_o
1	60%
2	78
3	86
4	93
5	96
10	105
Infinite	116

3. For a constant number of stages, the over-all efficiency increases with decreasing values of A.

No. of Stages	A	E_P	E_o	$(E_o - E_P)/E_P$
3	2.0	80	90	13
3	0.5	80	130	63

Therefore, low liquid reflux rates and high values of the slope of the equilibrium curve result in a larger per cent increase in over-all efficiency over the local efficiency. However, low liquid reflux flows decrease the number of stages and high values of the slope of the equilibrium curve give low values of local efficiencies.

Previously it was mentioned that Equation (4) (Lewis) equals Equation (5) when the number of stages is infinite. Since this never occurs, Equation (5) gives more reasonable results than the Lewis equation. Consider the following case: $m = 10$; $L/V = 1.0$; local efficiency = 35% and equilibrium and operating lines are straight.

Equation (5) gives an over-all plate efficiency of 66% when the number of stages is equal to 2.0. For eight stages and the same conditions, the over-all efficiency is 170%. On the other hand, Lewis's Equation (4) gives an over-all efficiency of 320%. Since for this example straight equilibrium and operating lines were assumed, Equation (6), shown later, may be used to estimate over-all column efficiencies. Thus for two stages, the over-all column efficiency is 83%; for eight stages, 125%. For E_o equal to 320%, the over-all column efficiency is 147%.

Method for Predicting Over-all Plate Efficiency

Equation (5) presents a convenient method for calculating the over-all efficiency if the local efficiency and the number of stages are known. Suggested methods for estimating the local efficiency and the number of stages are given below.

LOCAL EFFICIENCY

The determination of local efficiency is difficult. Most experimental local efficiencies are unreliable because of difficulties in sampling. Also many local efficiencies reported in the literature were calculated from over-all plate efficiencies by the Lewis equations.

At the present time the American Institute of Chemical Engineers is sponsoring a study of the factors affecting

* This is not rigorous, because as shown by Gerster (5) in Equation (2A), the efficiency is a function of the individual films resistances as well as the slope of the equilibrium curve. However, in many cases it has been found that with high slopes of the equilibrium curve the efficiency is low and conversely with low slopes the efficiency is high.

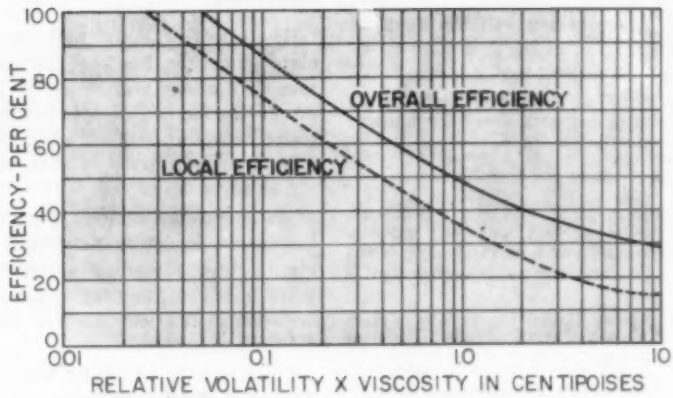


Figure 5. Plate efficiency as a function of relative volatility X viscosity.

—— Over-all efficiency [10]
----- Local efficiency (speculative)

plate efficiency. This study is designed to determine the fundamental factors that affect the local efficiency. However, until such data are available, it would be desirable to have an approximation of the local efficiency to demonstrate the utility of Equation (5).

The local efficiency may be estimated from Equation (2A).

$$\frac{1}{-\ln\ (1-E_P)} = \frac{1}{N_G} + \frac{ml'/L}{N_L} \qquad (2A)$$

Gerster (5) has shown how this equation can be applied by evaluating individual film resistances. However, more data are required before values of N_G and N_L can be calculated with confidence. An approximate solution of Equation (2A) can be obtained if certain simplifying assumptions are made.

The value of N_G can be eliminated from Equation (2A) based on the assumption that N_G is in the range of 1.5 to 3 for most commercial columns. Gerster's Figure 4 shows that for the humidification of air N_G is in this range for values of liquid depth and vapor velocity used in commercial columns. Also the practice of converting N_G from humidification of air to other systems is to assume that N_G is proportional to the Schmidt number to the one-half power. Also as Gerster (5) points out, the change of the Schmidt number for gases is not sufficient to change appreciably these values of N_G. Thus:

E_P is a function of $\dfrac{mV/L}{N_L}$.

For most commercial columns, V/L is practically constant. Further N_L is a function of the Schmidt number $(\mu_L/\rho_L D_L)$. Liquid diffusivity is also a function of viscosity, and N_L was assumed a function of viscosity. Thus

E_P is a function of m and μ.

Further in most cases, the slope of the equilibrium curve varies in the same manner as the relative volatility; that is, when the relative volatility is high, the slope of the equilibrium curve is high and the converse is true. Thus, the following relationship holds approximately:

E_P is a function of α and μ.

This is a similar correlation to one which one of the authors (10) plotted with the over-all column efficiency as a function of $\alpha\mu$ shown as the solid line on Figure 5.

The local efficiency may be derived from the over-all efficiency and from Equation (5) with the following assumptions:

1. The liquid path is 2.5 ft. and this gives approximately two stages. Most columns in the original correlation had a liquid path from 2 to 3 ft. The authors' guess was that for an average length of 2½ ft. there would be two stages. A different assumption would have shifted the curves in Figure 6 but would not have changed the conclusions.

2. The value of A for over-all column efficiencies around 90% is 0.8 and for over-all column efficiencies around 30% is 0.1. This follows, since at high efficiencies the slope of the equilibrium curve is usually in the range of 1 to 2, and at low efficiencies the slope of the equilibrium curve is usually in the range of 8 to 15. For a L/V ratio of 0.5 to 1.0, the value of A is approximately 0.8 at 90% efficiency and 0.1 at 30% efficiency.

3. Over-all column efficiencies and over-all plate efficiencies are equal. Equation (5) gives the relationship between local efficiency and over-all plate efficiency. The relationship between over-all column efficiency and over-all plate efficiency can be defined by a plate-to-plate calculation if the over-all plate efficiency is known. For the special case where the operating and equilibrium lines are straight, the following equation holds (14).

$$E = \frac{\ln\left[1 + E_o\left(\frac{1}{A} - 1\right)\right]}{\ln\frac{1}{A}} \qquad (6)$$

The dotted line on Figure 5 was determined with these assumptions and should give a reasonable estimate of the local efficiency within the limits described above.

distillation

Number of Stages

A method for determining the number of stages is necessary to evaluate Equation (5). This evaluation is made difficult because the concept of a stage of completely mixed liquid is a hypothetical one. Actually, the number of stages represents the degree of mixing on the tray. However, the following variables affect the number of stages.

1. The length of the liquid path. Obviously the longer the liquid path, the greater the num-

Table 1.—Effect of Liquid Path on Plate Efficiency

System	Ref.	Approx. Length of Liquid Path, ft.	$A = \frac{l}{Vm}$	Over-all * Column Eff.	Est. Local Eff. from Fig. 5	No. of Stages Calc. from Equation (5)
Isobutane-Butane	1	2.5	0.85	88%	73%	1.8
Isobutane-Butane	2	8	0.50	140	75	8
Hydrocarbons	3	4	0.85	82	65	3
Hydrocarbons	3	5.5	0.85	89	65	4.5

* For rigorous use of Equation (5), the over-all column efficiency should be converted to over-all plate efficiency. However, this would require plate-to-plate calculations which were not justified at this time for the additional accuracy obtained.

ber of stages.

2. The liquid rate. If the liquid were to flow across the plate unmixed, there would be an infinite number of stages and Lewis's equation would hold. The higher the liquid rate, the less mixing on the tray and the greater the number of stages for the same length of liquid path.

3. The design of the tray. Any tray design which minimizes mixing will increase the number of stages for the same liquid rate and the same length of liquid path.

4. Vapor rate. It has been pointed out that the vapor rate through the slots affects the turbulence and thus the degree of mixing.

There are few tests on fractionating columns with lengths of liquid path over 2.5 ft. Tests on four columns reported in the literature are summarized in Table 1. This table gives the values of A and over-all plate efficiencies which were obtained from the original references. The local efficiency was obtained from Figure 5 and from the physical properties of the system. The number of stages was calculated from Equation (5).

From these data the effect of liquid path on the number of stages was estimated. Such an estimation is shown in Figure 6 where the number of stages is plotted as a function of the length of liquid path for conditions which are conducive to good mixing (the "maximum mixing" line) and to poor mixing (the "minimum mixing" line). Data from Table 1 are plotted on Figure 6.

Figure 6 is only an approximation and is presented to demonstrate the principle proposed. Considerably more data are required to give a clear definition of these relationships.

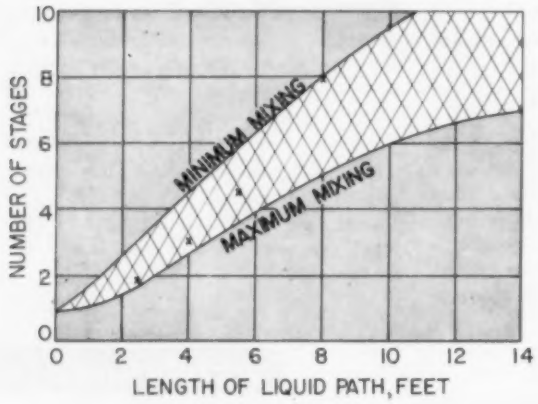


Figure 6. Effect of length of liquid path on number of stages.

Examples—Utilization of Proposed Method

1. The test results on a natural gasoline fractionator, Gunness (*6*), are used to demonstrate the utilization of this method.

System = propane-butane

Over-all plate efficiency = 100% (avg. of five tests)

Length of liquid path = 4 ft.

Relative volatility of system(α) = 1.7

Viscosity of system at average temperature and pressure (μ) = 0.095

$\alpha\mu = 0.16$

$A = L/Vm = 0.6$

a. From Figure 5 at a $\alpha\mu$ ratio of 0.16, the local efficiency from the dotted line is 67%.

b. From Figure 6 with liquid path of 4 ft. and a high liquid rate, the number of stages is 3.6.

c. Substituting into Equation (5):

$$E_o = A\left[\left(1 + \frac{E_P}{nA}\right)^n - 1\right]$$

$$E_o = 0.6\left[\left(1 + \frac{0.67}{3.6 \times 0.6}\right)^{3.6} - 1\right]$$

$$E_o = 0.95$$

This compares with a measured efficiency of 100%.

2. Shilling, Beyer and Watson (*16*) present both local and over-all efficiencies for the system alcohol-water. They report for a 45 mole % alcohol liquid leaving the plate, a point efficiency of about 85%. For this condition, $m = 1.3$, and for total reflux $A = 0.77$; and for partial reflux $A = 0.38$.

The length of liquid path is 1 ft. and from Figure 6 there is approximately 1.5 stages.

From Equation (*2*) the calculated over-all efficiency for total reflux is 100%. For partial reflux the calculated over-all efficiency is 111%. For 45 mole % alcohol in the liquid, Shilling et al. report between 100 and 120%.

The local efficiency reported by Shilling et al. cannot be predicted by Figure 5. This is explained by the fact that for this system the slope of the equilibrium curve is not proportional to the relative volatility. A correlation of plate efficiency vs. the slope of the equilibrium curve times the viscosity would give a better fit.

Conclusions

The effect of liquid path on over-all plate efficiencies has been shown. Equation (5) along with Figures 5 and 6 presents a method of approximating the effect of liquid path on plate efficiency. This method is given to show the qualitative effect only.

As mentioned above, Figure 5 has limitations in determining local efficiencies. Hopefully in the near future, work now being sponsored by A.I.Ch.E. will define local efficiency in fundamental terms.

Figure 6 is based on meager data. However, further data should not materially affect the range of the curves. Figure 6 will by necessity be semiempirical since it is based on a hypothetical concept, i.e., a stage is a pool of completely mixed liquid. For one who has seen an operating plate in action, it is difficult to define a specific pool of mixed liquid on a plate. Actually, each pool overlaps on each other and the performance could better be defined by the degree of mixing that occurs.

Acknowledgment

Acknowledgment is given to Professor Brymer Williams of the University of Michigan and to Professors J. A. Gerster and R. L. Pigford of the University of Delaware for valuable suggestions in the writing of this paper.

Notation

$A = L/Vm$

b = intercept in equilibrium relation

$B = VE_P m/nL$

D_L = diffusion coefficient in liquid phase

E = over-all column efficiency

E_o = over-all plate efficiency [defined by Equation (3)]

E_P = local plate efficiency

G = gas flow rate/unit of tray area, moles/(time)(area)

ka = film coefficient of mass transfer, lb. moles/(hr.)(cu.ft.)(unit mole fraction difference)

L = liquid flow, moles/time

m = slope of the equilibrium curve ($y_i^* = mx_i + b$)

n = number of stages in series

N = number of transfer units

V = vapor flow, moles/time

x = mole fraction in liquid

x_o = mole fraction in liquid entering series of stages

$\Sigma x = x_1 + x_2 + \cdots + x_n$

y = mole fraction in vapor; without a subscript, y = mole fraction in vapor entering each stage

$y' = y - b$

y_{av} = average mole fraction in vapor [defined by Equation (9) in Appendix]

$\Sigma y = y_1 + y_2 + \cdots + y_n$

y_n^* = mole fraction in vapor in equilibrium with liquid of composition x_n

Z = vertical distance on plate in which gas contacts liquid

α = relative volatility

μ_L = liquid viscosity

ρ = liquid density

Subscripts

1, 2, . . . , n—refer to stages 1, 2, . . . , n respectively.

G = gas film

L = liquid film

i = refers to point i on the tray

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Appendix

Derivation of Equation (5)

$$E_o = A\left[\left(1 + \frac{E_P}{nA}\right)^n - 1\right]$$

The following assumptions are made:

1. L and V/n are constant.
2. The vapor entering each stage has the same composition.
3. The equilibrium relation is $y^* = mx + b$.
4. The slope of the equilibrium curve is constant for the conditions of the tray.
5. $E_{P1} = E_{P2} = \cdots = E_P (= E)$.

In the following derivation, the reader is referred to Figure 1. The derivation is divided into three parts:

1. An expression for x_n is obtained.
2. An expression for y_{av} is obtained.
3. Results for x_n and y_{av} are substituted into the equation defining E_o to obtain the final result.

Obtaining an expression for x_n

By a material balance for stage 1,

$$Lx_o + \frac{V}{n}y = Lx_1 + \frac{V}{n}y_1 \qquad (1)$$

By definition,

$$E = \frac{y_1 - y}{y_1^* - y} = \frac{y_1 - y}{mx_1 - y + b} \qquad (2)$$

Rearranging (2),

$$y_1 = Emx_1 - Ey + y + Eb \qquad (3)$$

Combining (1) and (3),

$$x_1 = \frac{x_o}{1+B} + \frac{y'B}{m}\left(\frac{1}{1+B}\right) \qquad (4)$$

Where $B = \frac{VEm}{nL}$ and $y' = y - b$

Similarly

$$x_2 = \frac{x_o}{(1+B)^2} + \frac{y'B}{m}\left[\frac{1}{1+B} + \frac{1}{(1+B)^2}\right] \qquad (5)$$

Generalizing

$$x_n = \frac{x_o}{(1+B)^n} + \frac{y'B}{m}\left[\frac{1}{1+B} + \frac{1}{(1+B)^2} + \cdots + \frac{1}{(1+B)^n}\right] \qquad (6)$$

Equation (6) is simplified by noting that the expansion following $y'B/m$ is a geometric series, the sum of which is (*12*):

$$\frac{1}{B}\left[1 - \frac{1}{(1+B)^n}\right] \qquad (7)$$

Therefore,

$$x_n = \frac{x_o}{(1+B)^n} + \frac{y'}{m}\left[1 - \frac{1}{(1+B)^n}\right] \qquad (8)$$

Obtaining an expression for y_{av}

By definition,

$$y_{av} = \frac{1}{V}\left[\frac{V}{n}y_1 + \frac{V}{n}y_2 + \cdots + \frac{V}{n}y_n\right] \qquad (9)$$

$$y_{av} = \frac{y_1 + y_2 + \cdots + y_n}{n} \qquad (10)$$

$$y_{av} = \frac{\Sigma y}{n} \qquad (11)$$

Combining (11) and (3),

$$y_{av} = \frac{Em}{n}(\Sigma x) - Ey + y + Eb \qquad (12)$$

Σx is obtained as follows:

$$x_1 = \frac{x_o}{1+B} + \frac{y'B}{m}\left(\frac{1}{1+B}\right) \qquad (4)$$

$$x_1 + x_2 = x_o\left[\frac{1}{1+B} + \frac{1}{(1+B)^2}\right] + \frac{y'B}{m}\left[\frac{1}{(1+B)^2} + \frac{2}{1+B}\right] \qquad (13)$$

Generalizing,

$$\Sigma x = x_o\left[\frac{1}{1+B} + \frac{1}{(1+B)^2} + \cdots + \frac{1}{(1+B)^n}\right] + \frac{y'B}{m}\left[\frac{1}{(1+B)^n} + \frac{2}{(1+B)^{n-1}} + \cdots + \frac{n}{1+B}\right] \qquad (14)$$

The expansion following $y'B/m$ in (14) is a combined arithmetic and geometric progression whose sum is (*12*):

$$\frac{(1+B)^n(Bn-1)+1}{B^2(1+B)^n} \qquad (15)$$

Substituting relations (7) and (15) into (14), and combining (14) and (12),

$$y_{av} = \frac{Emx_o}{nB}\left[1 - \frac{1}{(1+B)^n}\right] + \frac{Emy'B}{nm}\left[\frac{(1+B)^n(Bn-1)+1}{B^2(1+B)^n}\right] - Ey + y \qquad (16)$$

Obtaining E_o in terms of E, A, and n

By definition,

$$E_o = \frac{y_{av} - y}{y_n^* - y} \qquad (17)$$

Using (6) for x_n in the denominator of (17) and simplifying,

$$y_n^* - y = \frac{mx_o - y'}{(1+B)^n} \qquad (18)$$

Using (16) for y_{av} in the numerator of (17) and simplifying,

$$y_{av} - y = \frac{E}{nB}(mx_o - y')\left[\frac{(1+B)^n - 1}{(1+B)^n}\right] \qquad (19)$$

When (18) and (19) are substituted into (17), the final result is obtained:

$$E_o = \frac{E}{nB}\left[\frac{(1+B)^n - 1}{}\right] \qquad (20)$$

$$E_o = A\left[\left(1 + \frac{E_P}{nA}\right)^n - 1\right] \qquad (21)$$

Presented at A.I.Ch.E. 46th annual meeting, St. Louis, Missouri.

ABSTRACTS

Abstracts of papers published in "Ion Exchange," Chemical Engineering Progress Symposium Series No. 14, Vol. 50 (1954), which may be obtained from Chemical Engineering Progress, 25 West 45 Street, New York 36, New York, for $3.25 for members and $4.25 for nonmembers.

Ion Exchange Equilibria of Sodium Chloride, Potassium Chloride, Water, and Dowex 50

J. A. Whitcombe, J. T. Banchero, and R. R. White
University of Michigan

Equilibrium data at 24° to 26° C. have been measured for the distribution of chloride ion between Dowex 50 and aqueous solutions of sodium chloride and between Dowex 50 and aqueous solutions of potassium chloride. The equilibrium resin-phase compositions were not measured directly but were determined by a material-balance procedure. Data were also obtained for the distribution of sodium and potassium ions between Dowex 50 and aqueous solutions containing both sodium chloride and potassium chloride at total salt concentrations from 0.0134N to 2.7N. Derived thermodynamic relations were used with the chloride-ion distribution data to estimate the activity coefficients of sodium chloride in the sodium resin and potassium chloride in the potassium resin.

Chemical Engineering Progress Symposium Series No. 14, Vol. **50**, 73 (1954).

A Countercurrent Solid-Liquid Contactor for Continuous Ion Exchange

I. R. Higgins and J. T. Roberts
Oak Ridge National Laboratory

A new type of continuous countercurrent ion exchange contactor has been developed and its efficiency demonstrated. It retains the high throughput characteristic of the conventional fixed bed since the solution flows are against a packed bed. The advantages of continuous, countercurrent flow are gained by periodically interrupting the solution flows momentarily to move the resin bed in slug flow with a hydraulic surge. This contactor should prove adaptable to other solid-liquid mass transfer processes as well as ion exchange.

Chemical Engineering Progress Symposium Series No. 14, Vol. **50**, 87 (1954).

Use of Ion Exchange in the Waste-Treatment Field

C. F. Paulson and A. B. Mindler
The Permutit Company

A variety of ion exchange steps applied to wastes have been investigated and applied commercially. These steps range from electroplating wastes to obtaining antibiotics from waste broths. Applications to date however have been spotty. A discussion of some of the applications indicates the results that may be expected from such processes.

Chemical Engineering Progress Symposium Series No. 14, Vol. **50**, 93 (1954).

Experimental Investigations of Ion Exchange Mechanisms in Fixed Beds by Means of an Asymptotic Solution

Leon Lapidus and J. B. Rosen
Princeton University

The concept of an invariant-concentration-time effluent curve associated with the rate function is applied to experimental data. Nonlinear isotherms for the particular ion exchange systems to be studied are first obtained in graphical or tabular form. Possible rate mechanisms are assumed which lead at equilibrium to the observed isotherms. The asymptotic solution of the resulting system of equations can then be obtained by evaluating a simple integral analytically or, if necessary, numerically, and the solutions can then be compared with experimental saturation curves obtained on laboratory columns of sufficient length and operating under such conditions as to minimize the effect of certain of the transport- or kinetic-rate steps.

Chemical Engineering Progress Symposium Series No. 14, Vol. **50**, 97 (1954).

Continuous Countercurrent Ion Exchange: I. Resin-Particle-Settling Rates in Spinner Columns; II. Mass Transfer Rates in Spinner Columns

W. W. Koenig, J. Olin, A. L. Babb, and J. L. McCarthy
University of Washington

As part of an investigation of methods by which ion exchange can be carried out continuously by use of ion exchange resin particles flowing countercurrently to a stream of liquid, a spinner column, chosen to minimize channeling of the liquid phase through the resin, was studied. Rates of settling of resin particles were measured experimentally, and it was found that the data were successfully correlated by use of six dimensionless groups, the relationship among them being expressed by an exponential equation. These correlations were then used to evaluate particle-settling rates in two spinner columns, one used for adsorption and the other for stripping of sodium ions, which were exchanged for hydrogen ions. The application of the results to the design of equipment is discussed.

Chemical Engineering Progress Symposium Series No. 14, Vol. **50**, 103, 111 (1954).

The six other Ion Exchange Abstracts were run in the February issue, page 73-F.

R. S. Montgomery, author, shown with part of mini-plant at Midland Division, the Dow Chemical Company.

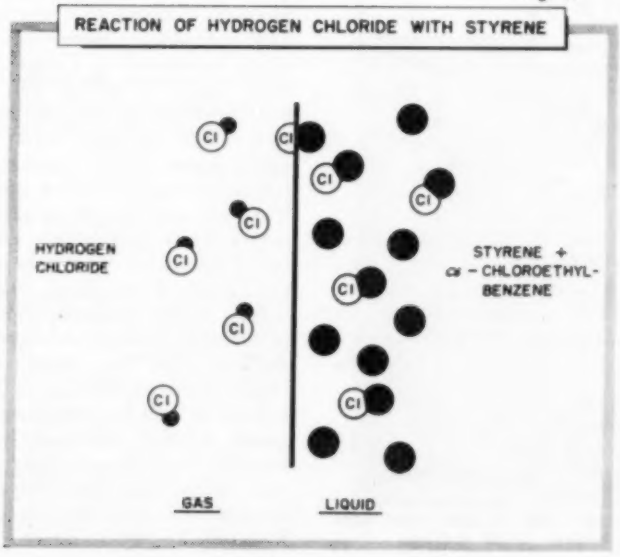
THE CONTINUOUS catalytic hydrochlorination of styrene

R. S. Montgomery | The Dow Chemical Company, Midland, Michigan

The work described in this paper was carried out for the purpose of designing a continuous process for the hydrochlorination of styrene. Hydrogen chloride may merely be sparged into styrene in a batch-type process, but this process is slow, excessively wasteful of hydrogen chloride, and requires large reactor volume for the amount of product produced.

An examination of the nature of this reaction reveals that anhydrous, gaseous hydrogen chloride reacts with styrene by addition across the vinyl double-bond to produce α-chloroethylbenzene.

Fig. 1.



$$C_6H_5CH : CH_2 + HCl \rightarrow C_6H_5CHCl \cdot CH_3$$

Figure 1 represents this reaction on a molecular level. The hydrogen chloride molecules diffuse from the main body of the gas to the liquid interface. Of the gas molecules striking the interface, only a portion react. This is true because some come in contact only with α-chloroethylbenzene molecules whereas others do not possess the required activation energy. The gas molecules which do not react diffuse back into the gas phase, while the newly formed α-chloroethylbenzene molecules diffuse away from the interface into the body of the liquid. From this discussion the reason for the slowing of the hydrochlorination rate as the reaction nears completion is apparent. It becomes increasingly unlikely that a hydrogen chloride molecule will encounter a styrene molecule at the interface since the proportion of these molecules has been reduced to a low level.

Examining this physical picture of the reaction in the light of the conventional "double-film" theory of gas absorption, and assuming the hydrochlorination reaction to be rapid, one can see that the so-called liquid film resistance is controlling. Since there is only one species of gas molecules, the gas film does not exist. This means that the reaction rate is limited by the rate with which the styrene molecules diffuse toward and the α-chloroethylbenzene molecules diffuse away from the interface.

Equipment

A packed column was selected for this work since this type of gas absorption equipment gives liquid-phase turbulence, is inexpensive, and is easily constructed of acid-resistant materials. A diagram of the column is shown in Figure 2. The styrene was pumped into the column at the top, the hydrogen chloride gas sparged in, and the reaction product removed at the base of the column. A small amount of hydrogen chloride was vented from the top of the column, but as there was no gas-film resistance the rate of gas flow did not affect the rate of the reaction. The column was water jacketed in order to control the temperature of the reaction and thereby to prevent the formation of polymer. Two columns were used in this study: One was $\frac{5}{16} \times 11\frac{1}{2}$ in. and the other 2×72 in. Both were made of glass. The temperatures of the inlet styrene stream and the outlet product stream was determined. In addition to this, a thermocouple was placed in the center of the larger column about 10 in. from the top of the packing.

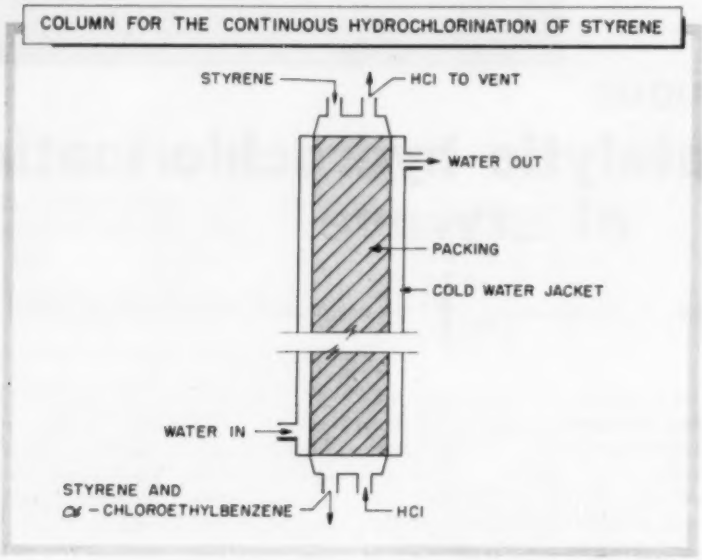


Fig. 2.

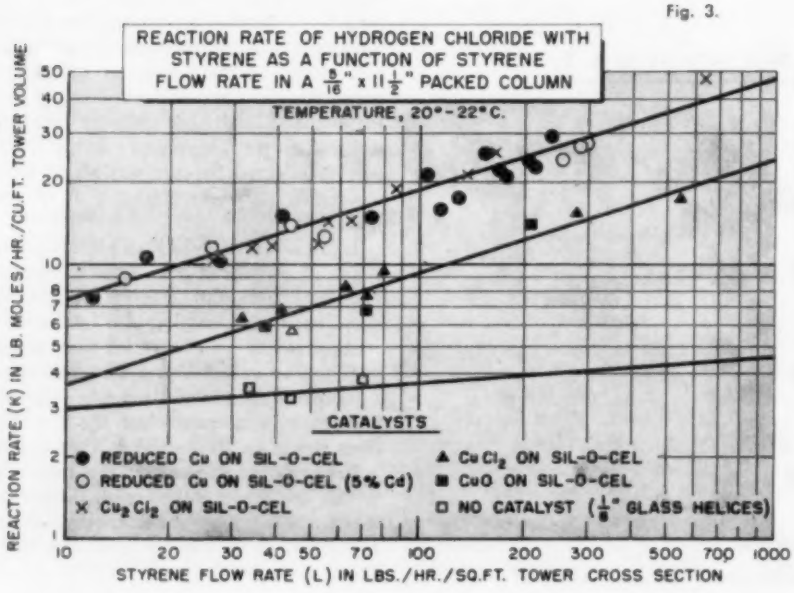

REACTION RATE OF HYDROGEN CHLORIDE WITH STYRENE AS A FUNCTION OF STYRENE FLOW RATE IN A 5/16" x 11 1/2" PACKED COLUMN
TEMPERATURE, 20°-22°C.
REACTION RATE (K) IN LB. MOLES/HR./CU.FT. TOWER VOLUME
STYRENE FLOW RATE (L) IN LBS./HR./SQ.FT. TOWER CROSS SECTION
CATALYSTS
REDUCED Cu ON SIL-O-CEL
REDUCED Cu ON SIL-O-CEL (5% Cd)
Cu2Cl2 ON SIL-O-CEL
CuCl2 ON SIL-O-CEL
CuO ON SIL-O-CEL
NO CATALYST (1/8" GLASS HELICES)

Fig. 3.

Catalysis of the Hydrochlorination

The reaction rate of the uncatalyzed reaction is rather slow and so, therefore, it is desirable to accelerate the reaction by the use of a catalyst. As the reaction rate is increased, the height of the column necessary to secure substantially complete conversion is decreased. The function of a catalyst in the hydrochlorination of styrene is to form a semistable complex with the hydrogen chloride molecules reaching the liquid interface and thereby increasing their concentration at the interface and, in some cases, to allow them to diffuse into the body of the liquid. In general, there are two types of catalysts which can be used to accelerate the hydrochlorination of styrene: (1) an inorganic material which remains on the surface of the packing and (2) a soluble organic compound which is added to the column feed.

INORGANIC CATALYSTS

The inorganic catalysts investigated were all copper or copper salts. The reason for this is that copper tends to inhibit the polymerization of styrene (*1*) and the copper salts are not so active polymerization initiators as are the usual hydrochlorination catalysts such as ferric chloride. The inorganic catalysts were all deposited on the surfaces of pieces of Sil-o-Cel and these pieces were used as packing in the column. For the control runs ⅛-in.-glass helices were used in the smaller and ¼-in. Berl saddles were used in the larger column. Styrene was pumped into the column at various rates and the conversion to α-chloroethylbenzene (moles α-chloroethylbenzene out/moles styrene in) was determined for each of these rates by measuring the density of the effluent liquid since the proportion of α-chloroethylbenzene in the styrene is conveniently determined in this way.

When reaction rates are plotted as functions of the styrene flow rates in the $5/16 \times 11\frac{1}{2}$-in. column on log-log paper, as shown in Figure 3, straight lines result. It can be seen also from this figure that the divalent copper catalysts fall on one curve while the monovalent copper catalysts and copper itself fall on another somewhat higher curve. The fact that copper is grouped with monovalent copper salts is probably due to the formation of cuprous chloride on the surface of the copper catalyst by the action of the hydrogen chloride. Use of a copper catalyst was investigated in the larger 2×72-in. column with results similar to those obtained in the smaller column as can be seen from Figure 4. Some difficulty however was experienced in controlling the column temperature in this case and, therefore, small amounts of polymer were frequently found in the effluent liquid.

ORGANIC CATALYSTS

Various organic compounds have been known for some time to be hydrochlorination catalysts (*2*). The activities of these materials were investigated in a slightly different manner from the manner of investigating the activities of the inorganic catalysts. Before making any continuous runs in a gas absorption column, small batch runs were made by sparging hydrogen chloride into styrene containing a small amount of catalyst for 1 hr. The amount of conversion of the styrene to α-chloroethylbenzene in this length of time is a measure of the activity of the catalyst. Twelve compounds representing most of the classes of organic compounds were evaluated, but as can be seen from Table 1, only these compounds containing hydroxyl groups showed important activities.

The catalytic activity of an organic compound probably depends upon two factors. It must form a loose addition compound with hydrogen chloride, yet it must be nonpolar enough to be completely miscible with styrene. The hydroxyl group containing catalysts form a series in their properties extending from isobutanol through the glycols to the end member of the series, water. It seems clear that the hydroxyl group is the portion of these compounds involved in forming the addition complex with hydrogen chloride. If this is the case, the catalytic activity would be expected to increase as the proportion of hydroxyl groups in the catalyst increases until the proportion of hydroxyl groups becomes so large that the catalyst becomes immiscible with styrene and its activity therefore decreases. Since the cohesive energy density (internal energy per cc. of liquid) of these hydroxyl compounds is a measure of the proportion of hydroxyl groups, it would seem that the catalytic activity should be a function of the difference of cohesive energy densities of the compound and styrene. Cohesive energy density (cal./cc.) is defined by the following equation:

$$c.e.d. = \frac{\Delta H^v - RT}{V} \qquad (1)$$

where

ΔH^v = heat of vaporization, cal./mole
R = gas constant, cal./mole, ° K.
T = absolute temperature, ° K.
V = molal volume, cc./mole

The activities of the hydroxyl group catalysts from butanol to glycerol are plotted in Figure 5. Actually, $(\delta_{CAT.} - \delta_{STYRENE})^2$, where $\delta = \sqrt{c.e.d.}$, has been used instead of the simple difference of cohesive energy densities since this quantity is more theoretically significant. As can be seen from Figure 5, the catalytic activities increase with increasing numbers of hydroxyl groups per gram to an optimum at methanol. As the number of hydroxyl groups per gram increases still further, the activity falls off sharply. It is reasonable that this should be so because the hydroxyl groups are the actual catalysts and,

Table 1.—Effect of Organic Catalysts on Conversion of Styrene to α-Chloroethylbenzene

Catalyst	% Conversion
glycerol	11.5
ethylene glycol	18.0
methanol	57.5
ethanol	50.5
isobutanol	43.0
1-methoxy-2-propanol	22.0
ethyl ether	19.0
ethyl acetate	17.0
acetic acid	15.0
acetone	18.0
formaldehyde	15.0
ethylene dichloride	16.0
none	10.0

Temperature, 20°-22° C.
Time, 1 hr.
Catalyst conc. 1.6% by weight.

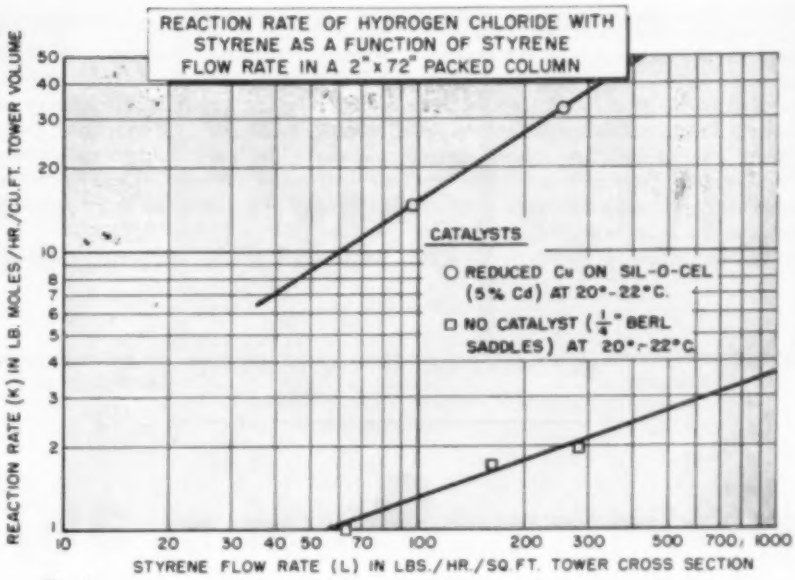
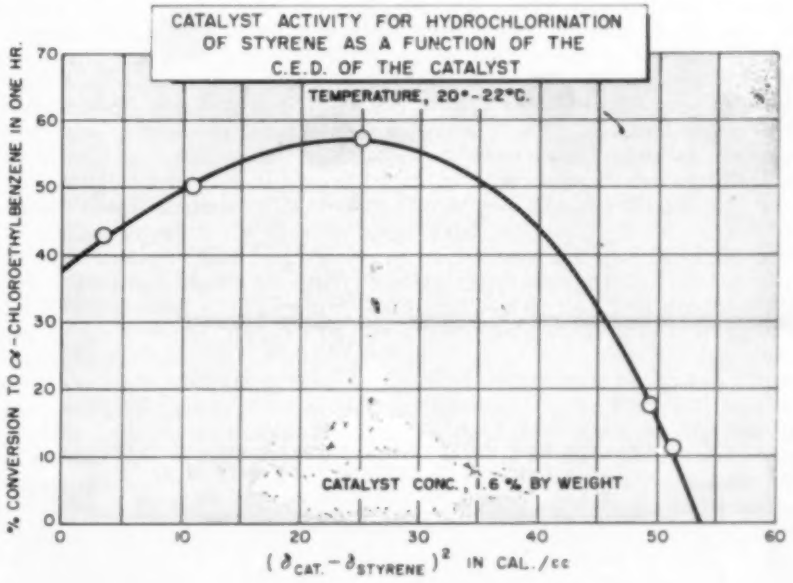

REACTION RATE OF HYDROGEN CHLORIDE WITH STYRENE AS A FUNCTION OF STYRENE FLOW RATE IN A 2"x72" PACKED COLUMN
CATALYSTS
○ REDUCED Cu ON SIL-O-CEL (5% Cd) AT 20°-22°C.
□ NO CATALYST (¼" BERL SADDLES) AT 20°-22°C.
REACTION RATE (K) IN LB. MOLES/HR./CU.FT. TOWER VOLUME
STYRENE FLOW RATE (L) IN LBS./HR./SQ.FT. TOWER CROSS SECTION

Fig. 4.

processes

Fig. 5.


CATALYST ACTIVITY FOR HYDROCHLORINATION OF STYRENE AS A FUNCTION OF THE C.E.D. OF THE CATALYST
TEMPERATURE, 20°-22°C.
CATALYST CONC., 1.6 % BY WEIGHT
% CONVERSION TO α-CHLOROETHYLBENZENE IN ONE HR.
(δCAT. − δSTYRENE)² IN CAL./cc

therefore, the catalytic activity of a compound should increase with the concentration of these groups. The low activities of ethylene glycol and glycerol can be attributed to the large differences of cohesive energy densities between these compounds and styrene. When the cohesive energy density difference between two compounds is large, they tend to be immiscible in each other. Whereas ethylene glycol and glycerol are not actually immiscible with styrene, it is believed that their decreased catalytic activity is due to an agglomeration of several molecules together to form micelles. The hydroxyl groups, because of their polar character, would be turned in toward the center of these micelles as in Figure 6. This would reduce the number of available hydroxyl groups and, therefore, the catalytic activity of these compounds.

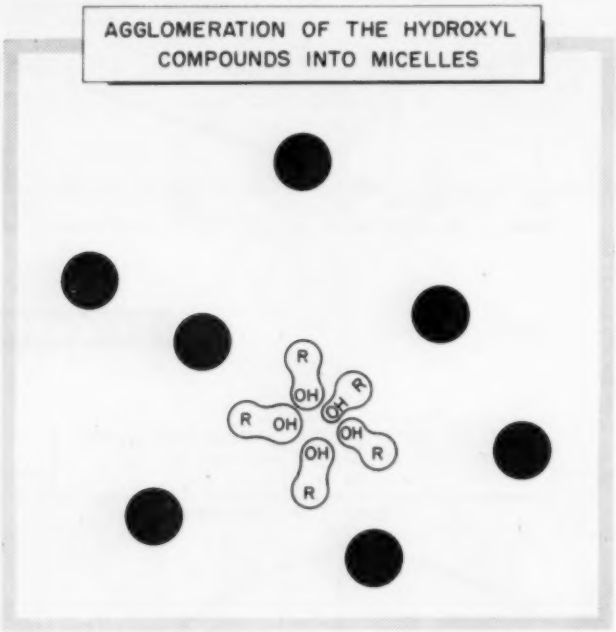
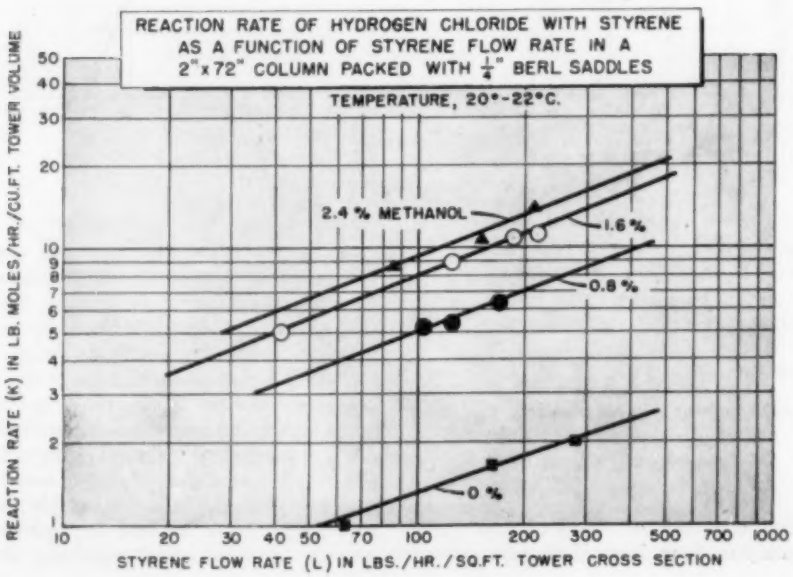


Fig. 6.

After it had been determined that methanol was the most suitable soluble organic catalyst for the hydrochlorination of styrene, several runs were made by the use of various amounts of methanol in the styrene feed in the 2×72-in. column packed with ¼-in. Berl saddles. The reaction rates have been plotted as a function of the styrene flow rates for these runs in Figure 7. As can be seen from this figure, there is a straight line correlation on log-log paper between these quantities. As expected, the reaction rate increased with increasing styrene flow rate. In addition to this, it was found that the hydrochlorination rate increased as the amount of methanol added was increased, although the amount of the increase diminished as more and more methanol was added. There is little to be gained by increasing the amount of methanol beyond 2%.

Fig. 7.



Conclusions

Styrene can be continuously hydrochlorinated in a packed column but at somewhat low reaction rates. These rates, however, can be accelerated by the use of either insoluble inorganic catalysts deposited on the surface of the packing or soluble organic catalysts added to the column feed. Copper and cuprous salts were found to be the most effective insoluble catalysts of those evaluated and methanol was found to be the most effective soluble catalyst. Little increase of reaction rate was obtained by increasing the methanol concentration beyond 2%.

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2. Finkelstein, H., and W. Krey, U. S. Patent 1,998,538 (April 23, 1935).

Presented at A.I.Ch.E. 47th annual meeting, New York.

Correction

An inadvertent error on p. 37 of the January, 1955, issue, the Lead Reference Sheet (Part 1), transposed headings in the chemical composition chart at the bottom of column 2. The columns should read, l. to r., "chemical lead," "acid lead," and "copper lead."

In this connection, the American Society for Testing Materials Committee B-2, Subcommittee II, are now voting on a proposed revision of these specifications. The revision involves eliminating the separate specifications for acid and copper leads, and combining them under the name "acid copper lead" with a silver maximum of 0.002, arsenic, antimony, and tin a combined maximum of 0.002, and zinc maximum of 0.001%.

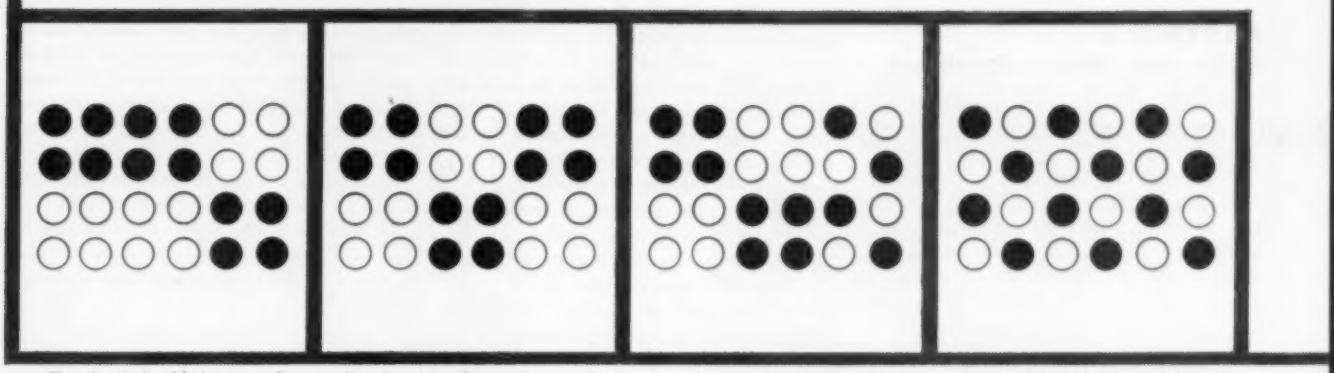


Fig. 1. A jumbled mass of aggregates.

Fig. 2. A uniform mixture of aggregates.

Fig. 3. A mix of aggregates and ultimate particles of the same analysis as Fig. 2.

Fig. 4. Illustrates the ideal uniform mix of ultimate particles.

MIXING in muller-type mixers

H. Leslie Bullock | Bullock-Smith Associates, New York

Muller-type mixers are suitable for both dry and wet materials over a wide range of density and viscosity. However, the range is quite definite because, if the mix becomes too fluid, there is not enough friction to rotate the muller wheels and their mulling action ceases, whereas if the mix becomes too sticky, the materials build up in front of the plows and are not folded over to release in front of the wheels for the mulling action. The too-fluid stage of failure to achieve the mulling action may be due to either suspension in a liquid or to the bulk presence of an extremely light, dry, free-flowing material of fine mesh. Such a free-flowing material does not have enough strength to support the mullers nor enough frictional drag to produce their rotation.

Mixing requirements may be considered as ranging from volumetric mixing to intensive blending. Volumetric mixers of the cone or vee-blender type, ribbon mixers, cascade mixers, and pony mixers are designed so that no pockets or dead spots of material can occur and they will produce uniform mixes of the ingredients in much the same state as they are fed into the machine.

Where aggregates are present in the feed which must be broken down, where wide differences of density or particle size require frictional anchorage of one powder or another, and where it is desired to increase the density of the final mix, intensive mixers are required. Sigma-blade mixers, Banbury mixers and muller-type mixers are all considered intensive mixers. As the efficiency of the sigma-blade mixers depends to a great degree on a stretching and folding action, these mixers do not work efficiently with non-tacky materials and are little used for dry-powder blending and, as the Banbury mixers are, in effect, modified sigma-blade machines used to smear tough, sticky, plastic materials onto dry powders in a confined space, they are not regarded as efficient mixers for the range of blends covered in this paper.

MIXING—what is it?

Mixing has been defined as "the manipulation of a heterogeneous mass of two or more materials so that an homogeneous product is obtained which is uniform both as to analysis and structure" (*1*). The size of the sample required to provide repeated uniform analyses is an inverse measure of the uniformity of the mix. The uniformity of both analysis and structure is stressed in the above-quoted definition because most samples for check analysis are large in comparison to the particle size of the basic constituents and it is possible to obtain uniform analyses with mixes which are not blended uniformly enough to promote uniform chemical reaction, to provide maximum strength in pressed articles, to achieve correct electrical or magnetic properties, or to produce maximum and uniform color development. This is due to the fact that practically all material powders are composed of aggregates much larger in

size than the basic particles. A uniform mix of these aggregates will check out very well with chemical analysis, but such a mix may be unsatisfactory as a feed to a reactor, as a feed for molding presses, as an electronic material, or as a colored product giving maximum degree of shade for the amount of expensive pigment included in the formula.

The difference between a uniform mix of aggregates and a uniform mix of ultimate particles is shown in Figures 1, 2, 3 and 4. Here the X's and O's represent ultimate particles of different ingredients and mass groupings of the same letter indicate aggregates. Figure 1 shows a jumbled mass of aggregates. Figure 2 shows a uniform mixture of aggregates. Figure 3 shows a mix of aggregates and ultimate particles of the same analysis as Figure 2, and Figure 4 illustrates the ideal uniform mix of ultimate particles. Intensive mixing with friction, crushing and/or impact forces, sufficient to break down the ingredient aggregates, is necessary to approach the perfection shown in Figure 4. Mixing by mulling combines three different simultaneous actions (1) consisting of a crushing of aggregates, (2) a frictional rubbing of the ingredients to produce intimate contact, and (3) a turning over of the entire mass of material to insure volume blending and to furnish a uniform feed to the mulling surfaces.

The old-fashioned mason mulled his plasters and cements carefully. He obtained his volume mixing by shoveling progressively from the edge to the center of the mix and he obtained an added mixing action by turning the shovel upside down and scattering the material over the entire pile. He then produced a mulling action on the materials by drawing the smooth underside of his shovel over the surface of the pile which effected an intimate blending of the particles and a densification of the tossed mass while, at the same time, if any smears appeared where the shovel was drawn over the surface, the mason knew that further volume mixing was necessary.

Modern muller-type mixers are designed to accomplish mechanically, quickly, and uniformly what the mason did slowly with backbreaking labor. Muller-type mixers consist of a pan for handling the batch, one or two muller wheels for producing the rubbing and crushing action, and inside and outside plows to fold over the material and to return it to the muller path. Mixers of this type can be obtained either with rotating pan, with the muller and plows rotating around a central turret in a stationary pan, or with both pan and mixing implements rotating in reverse direction. As it is the relative motion of plows, muller wheels, and pan which produces the desired mixing action, the exact layout of the moving parts may be considered merely a matter of individual manufacturing preference; hence in this paper the line drawings will be confined to the simple stationary pan-type mixer, with the mullers and plows revolving around a central turret.

Individual manufacturers' design preferences will be indicated by the photographs.

OPERATING CONDITIONS

To be effective, mixers of all types should fulfill four fundamental operating conditions

1. **The mixer body must satisfactorily hold the ingredients of the mix.**
2. **Motion of the mixer or its blades must move the ingredients progressively into the active mixing zone.**
3. **Primary elements of the mixer must work on the material in the active zone in a manner and with an intensity sufficient to produce the desired degree of mixing.**
4. **The mixer must empty itself quickly and cleanly.**

Figs. 5 and 6 show general location of the various parts.

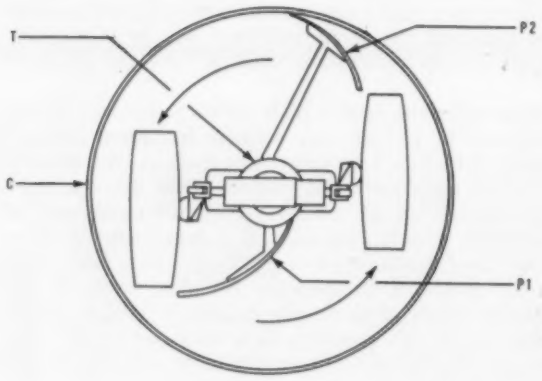


Fig. 5. A plan view.

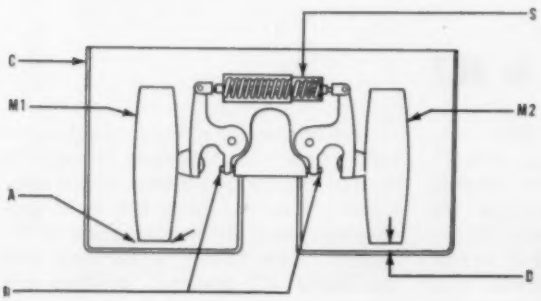
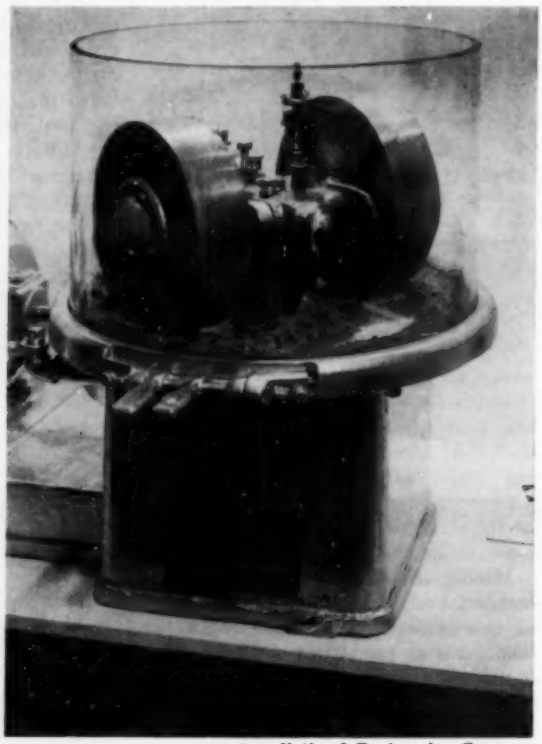
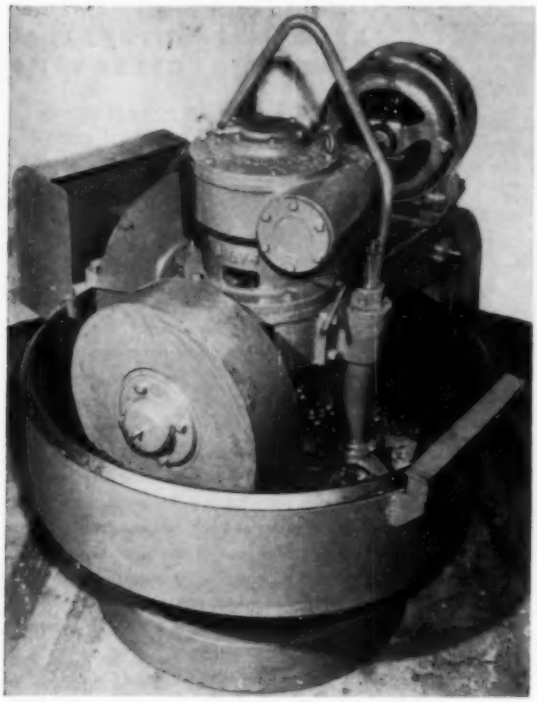


Fig. 6. A sectional elevation of a typical unit.

Fig. 7. Laboratory mixer with transparent crib. Note: 1—burnished path of muller wheel; 2—action of inside plow.



courtesy National Engineering Company



courtesy Clearfield Machine Company

Fig. 8. Muller-type mixer with auxiliary rotating wheel on vertical shaft.

courtesy Posey Iron Works Inc.

Fig. 9. View showing open bottom discharge with overlapping plow.

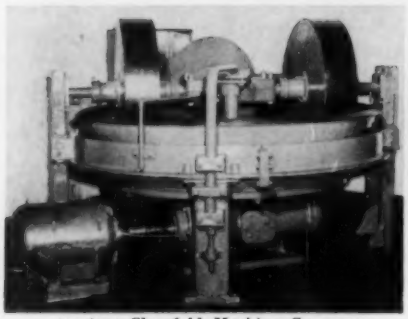
In muller mixers, design is a matter of compromise and each manufacturer has worked out rough rules for proportioning the active mixing zone area to total pan area and for the location of the active mixing zone. Reference to the line drawings, Figures 5 and 6, shows the general location of the various parts. Figure 5 gives a plan view and Figure 6 shows a sectional elevation of a typical unit. These drawings show the pan or crib C, muller wheels M1 and M2, turret T, the pressure area A between the muller and the bedplate, the distance setting D of the muller above the bedplate, screws B for adjusting the distance setting *D*, and compression spring S for regulating the pressure of the muller wheels. The unit shown is arranged for counterclockwise rotation.

In the particular model shown, the muller pressure is produced by the compression spring S and is adjustable. The active intensive mixing zone is in the pressure area A directly between the cylindrical surface of the mullers and the bedplate. The work which can be accomplished in this zone is a function of the pressure of the muller on the material, the width and diameter of the muller wheel, the distance it is set above the bedplate D, and its speed of rotation around the turret. The muller pressure, the distance between the muller and the bedplate, and the speed of rotation are adjustable between rather wide limits. As the intensive mixing is accomplished on the small volume of material between the curved surface of the muller and the bedplate, a short mixing cycle demands that the ratio of the amount of material in the compressed muller track to the total amount of material in the mixer charge be kept high. On the other hand, as this is a batch operation, it is important that the mixing time, rather than the loading and unloading time, should govern the productive rate, and it is not economically advisable to use the largest muller which may be fitted into a given pan or crib. Since the volumetric mixing and the movement of the ingredients into the active zone are accomplished by the plows and as they can be made efficient over a wide range of crib area, the real limiting factor in design is the ratio of the amount of material in the compressed muller path to the total volume in the mixer.

Each manufacturer seems to have different ideas as to the economical ratio and, since there are many other variables affecting production, good results can usually be obtained when mixing a great variety of materials. Once the static design points of crib diameter, turret diameter, radius of muller path and width and diameter of the mullers for a particular model are set up, other variable factors can be used to adjust the mixer to the mixing problem under consideration. The pressure of the mullers on the material may be adjusted by changing the actual weight of the mullers or by adjustment of the spring S.

The clearance between the mullers and the crib bedplate may be set by the use of shims or of a distance screw, and the speed of rotation can be changed up to the limits set by centrifugal force or power consumption.

As the development of muller-type mixers for general manufacturing purposes is comparatively recent, the basic design rules and the rules for the setting of variable adjustments are empirical. Some day, no doubt, there will be a series of formulas which will govern basic design, horsepower requirements, heat development, and time of mixing for a wide range of materials. These formulas will be complicated since, besides mechanical dimensional factors, they will have to include factors



courtesy Clearfield Machine Company

Fig. 10. Open-top mixer showing adjustable combination mixing and discharge disc at back of mixing pan.

covering the specific gravity of the ingredients, the mesh sizes, surface characteristics, degree of densification, and changes of viscosity with the addition of liquids. In the meantime, one will have to be content with careful laboratory testing to determine the most efficient operating conditions with standard equipment.

As the muller wheels are broad-faced and rotate around the turret in a short radius curve, only one circumference line on the muller face meshes exactly with the material on the pan bottom. Inside of this line the surface of the muller drags the material backwards, and outside this line the material is dragged forward. This relative motion produces a rotary smearing action on the material and tends to blend the ingredients into extremely intimate contact with each other. (See muller path in Figure 7.) The crushing action of the muller wheels pushes the material out of the muller orbit, and the plows are provided to return it to the muller path and to fold it over on itself to produce efficient volume blending. For some types of material an additional rotary-mixing element on a vertical shaft is provided (Figure 8). Dry materials do not have enough cohesion to produce uniform folds of material, hence the layers are broken down as the folding-over action proceeds. This materially aids the volume blending. If the layers were of sufficient strength to allow a perfect fold-over, one would be duplicating the action of the baker in producing flaky pie crust by folding and rolling the dough. This would of itself produce excellent volume blending since the number of layers doubles with each passage of the plows and, theoretically, more than 260,000 layers are produced by the two plows in ½ min. with the mixer rotating at 39 rev./min.

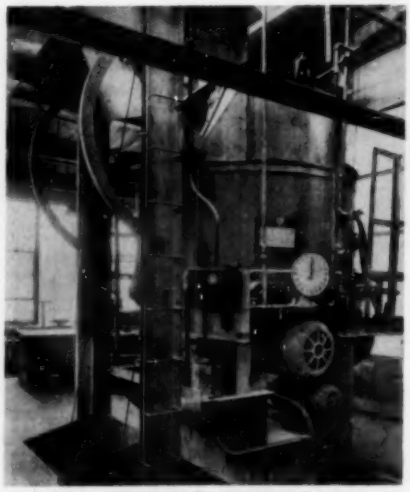
When it is considered that the folding and stirring action of the inside and outside plows is followed directly by the crushing and rotary rubbing action of the muller wheels, it is easily seen that a thorough mixing action is produced in an exceedingly short time in muller-type mixers. In some types of mixer, when the mixing cycle is completed, the plows serve as an effective means for unloading the mixer through a discharge door in the bottom of the pan. The plows overlap this discharge door and, when the door is opened, the rotation of the plows draws the material into line with the door and delivers it to the opening.

courtesy National Engineering Company

Fig. 11. Laboratory mixer with cover.

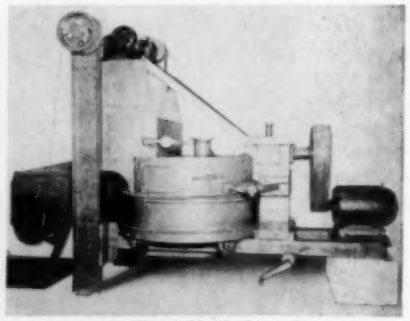
Some moving-pan mixers are arranged for discharge through a centrally located hole in the bottom pan by the use of the relative motion of the plows to direct the mixed material to the outlet (Figure 9); in others, a disc is placed between the mullers on a movable support (Figure 10), which allows either face of the disc to be presented to the material in the moving pan. When the inside face is presented to the flowing material, the disc serves as a plow to direct the material back into the muller path. When the outside face of the disc is presented to the flowing material, a sloping discharge ramp is produced which raises the mixed material from the pan and directs it into an external discharge chute.

Standard muller mixers range in capacity from a fraction of a cubic foot up to more than 60 cu.ft. and have muller wheels weighing from 45 to 4,000 lb., driven by motors of ¾ to 75 hp. Figure 11 illustrates a laboratory unit having a capacity of ¼ to ½ cu.ft., and Figure 12 shows an enclosed unit of 5- to 7-cu.ft. capacity, arranged for automatic control of the mixing cycle and for metering the liquid ingredient. Figure 13 illustrates a compact unit fitted with bucket loader and exhaust hood. Open-type mixers are standard construction, but enclosed models in plain or jacketed constructions are available for work at controlled temperatures, under either pressure or vacuum. A jacketed vacuum mixer is illustrated in Figure 14. Materials of construction can, of course, be selected to meet processing requirements.



courtesy National Engineering Company

Fig. 12. 5- to 7-cu.ft. capacity enclosed mixer with open bucket loader and automatic controls.



courtesy Clearfield Machine Company

Fig. 13. Compact unit fitted with bucket loader, exhaust hood and crank operated discharge.

MULLER-TYPE MIXERS IN VARIED FIELDS

Muller-type mixers were first known as putty chasers and end-runners and were mainly used for blending oils with fillers, for mixing black powder, and for plasticizing clays. The value of the frictional rubbing muller action was next appreciated by the foundry industry in applying small amounts of finely divided binder materials to sand particles for both core and molding sand mixing. The widespread use in the foundries attracted the attention of engineers having contacts in other industries and, during the last 20 to 30 years, these mixers have proved their worth in many chemical, electrical, food, and cosmetic applications. Exceedingly large tonnages are handled by these mixers in the ceramic, refractory, insecticide, and lead pencil manufacturing fields in particular. The electronic industry has lately become a volume-user of this equipment for mixing magnetic materials, semiconductive materials, and insulating materials carefully to control uniformity and density for high-frequency work.

The rapid increase in the use of muller-type mixers has paralleled the availability of raw materials of guaranteed purity and of uniform, fine particle size. Development of these materials has taken place in the last 30 years, and the writer remembers that only 24 years ago, in 1931, a high official of one of the large chemical companies complained that the importation of uniformly graded German chemicals was forcing them to manufacture and grade to closely controlled particle size.

As pure, closely graded, finely ground materials became available, industry after industry adopted the mulling principle of mixing. Dry materials of high uniformity can be weighed so accurately that chemical specifications may be held within narrow limits. Thorough mixing of the dry ingredients of a batch becomes a matter of 2 to 7 min. and wet additions are evenly distributed in 5 to 15 min. after they have been poured into the mix.

An example of improvement in processing through the use of muller-type mixers is given by the ceramic industry. Old methods of manufacture included wet ball milling or plunging, screening, filter pressing, drying, and tempering. In the new mulling process the dry ingredients are accurately weighed into the mixer and mixed dry from 3 to 5 min. The necessary water is added and the mixing continued from 5 to 15 min. The material is ready then for pressing into wall or floor tile, whiteware, electrical porcelain, and refractories.

courtesy National Engineering Company

Fig. 14. Variable speed, jacketed mixer for vacuum or pressure operation.

ECONOMIES EFFECTED

A typical example of the economies made possible by the substitution of muller-type mixing is given in Table 1. It should be noted that, though the material for the manufacture of tiling, whiteware, insulators, and electrical porcelain must be finely ground, this requirement does not hold for the abrasive, brick, refractory and similar industries, or where surface configuration is not important. Large particles may be incorporated in the mix if the formula is correctly developed to provide surface coverage of the larger pieces and to include sufficient binder to give necessary strength.

In the plastic field, the influence of natural rubber was noted in the early equipment designed to heat, soften, tear, fold, and smear a tough, viscous mass and wrap it around the other ingredients of the mix. Now that a large portion of plastic resins can be obtained in a free-flowing state for compounding, the viscous plastic state can be avoided and a uniform blend of resin, plasticizer, lubricant, fillers, and pigments can be made quickly in relatively lightweight equipment. If the blend is to go to rolls, Banbury mixers, or other heavy equipment for complete fluxing, the muller mixer may be fitted with a heating jacket and the blended material brought to a temperature just under the softening point. This procedure saves time in the heavy duty, high-powered equipment and there is a further economy in that heat from direct combustion is much cheaper than frictional heat such as that developed in the Banbury model during the stage when hard particles are being softened by the rubbing action of the blades. A combination of heat and vacuum is desirable sometimes for the blend can be efficiently dried while the plows are continually exposing new surface in the mixer crib.

Pencil leads of exceptional uniformity are produced by muller mixing. There is sufficient crushing action under the mullers to break down filter cake, and green extruded lead scrap may be returned to the mix in a fairly large amount. After the blend is completed, controlled evaporation from the mix allows uniform drying throughout the mass and, as the mixer can be quickly discharged into a closed conveyor or container, it can be delivered to the extruder with just the right amount of moisture. Since fast extrusion of perfect leads is only possible when the right amount of moisture is present, this feature is important.

The food industry was one of the last converts to muller mixing but it is now widely recognized as an efficient means to economize in the amount of flavoring and shortening required in a cake mix, to produce a uniform blend of spices with an extender, and to mill chocolate compounds under closely controlled atmospheric and temperature conditions.

mixing

Muller-type mixing is also extensively used for blending materials prior to pressing of shapes prepared for sintering or of briquettes prepared for reducing furnaces. In these operations it is imperative that the materials be uniformly mixed, that there be extremely close contact of particles, and that a minimum of binder material be used. These conditions are well met by muller mixing.

In this field products range from briquetting material prepared for the reduction of zinc, manganese, etc., to metal powders blended with the proper lubricant to insure good pressing and of a uniformity which will produce the practical equivalent of an alloy when sintered at the proper temperature.

Interaction of chemicals in the gaseous state is, of course, an ideal condition, with gas and liquid interaction coming next, liquid-liquid in third place, liquid-solid in fourth place, and solid-solid coming last. However, in the modern chemical world, it is often functionally or economically necessary to employ solid-solid interactions. In this type of reaction intimate surface contact is of first importance and the smearing action obtained in the muller mixer produces excellent results. This is proved historically by the fact that in the manufacture of gun powder, which was one of the first solid-solid reaction materials, large, so-called end-runner mills having wooden muller wheels up to 6 ft. in diam., revolving around a center post on a 4 ft. to 6 ft. radius, were used to blend the charcoal, sulfur, and saltpeter. Modern units of special design now produce rocket powders, pyrotechnic mixes and similar materials. Units of standard design may be used for solid-solid interaction mixes in the fields of solid catalysts, consumable electrodes, and other applications where the materials are not sensitive to heat or shock.

Due to the extremely rapid mixing action in muller-type mixers and the wiping action of the muller wheels, plows, and scrapers, uniform acidulation of solids is obtained, either as part of a general mixing action or as a primary operation. When acidulation is part of a general mixing operation, the practice is to mix the dry materials for 2 to 3 min. before starting the addition of the acid. The acid is run in just in front of the muller wheels and, in many cases, its absorption and neutralization by the dry material are so rapid that mixers of ordinary iron and steel construction may be used. When acidulation is the primary operation, the efficient mixing action of the muller mixers is used to distribute quickly the acid-bearing particles throughout the mass to produce a uniform product containing no free acid. If the acid is added at the proper rate, balling or lumping of the material is avoided and the discharge is made up of free-flowing granules.

In applying these muller-type mixers to new fields, the standard design of the old putty chasers has been modified extensively to allow controlled mixing of sensitive products. Thus, in mixing friable ingredients where there must be a minimum breakdown of the particles, lightweight aluminum mullers have been developed to limit the crushing effect and reduce the unit friction. In the explosives, rocket powder, and pyrotechnic fields, it has been necessary to limit the generation of frictional heat and this has been accomplished by regulating the pressure, the areas of contact, and the relative speed of frictional surfaces. Changes of design have been made also to avoid any chance of producing sudden shock between the muller wheels and the working surface of the pan. Special bearings and enclosures have been designed also to allow vacuum and pressure operation.

Consonant with all mixing operations, the successful use of muller-type mixers requires a careful study of the ingredients of the mix, their correct physical preparation, and their addition to the batch in the proper order. Some finely powdered ingredients, such as carbon black, contain a large quantity of air. This will be slowly removed in part by the densifying action of the mixer, but it can be accomplished much more quickly by wetting the powder with a light solvent, if such an addition to the mix is permissible. Ingredients containing large, hard aggregates should be placed in the mixer and mulled for a minute or two before the other ingredients are added as the other ingredients might otherwise produce a cushioning effect and interfere with the rapid and uniform breakdown of the aggregates. If any of the solid materials which are present in small amounts are soluble in any liquid portion of the batch, it is well to dissolve them, add them to the mix in the liquid form, and of course to make provision to distribute the liquid uniformly over the surface of the mix. Where a trace of material is to be added—and it is not soluble in any other ingredient of the mix—it is sometimes necessary to add it as a dilute solution in a neutral solvent with provision made to evaporate the solvent at the completion of the mixing cycle. If a liquid monomer is part of the formula, it is important that the polymerization catalyst be distributed uniformly throughout the monomer and not be lost in the mass of the other ingredients. The monomer and the catalyst should, therefore, be thoroughly mixed as a separate operation and added to the batch as a unit. Where chemical action takes place in the mix, provision must be made for the removal of fumes, and means should be at hand for the necessary temperature control.

Muller mixing is definitely indicated where uniform products are made, for direct delivery to the consumer, in which the potency, color, density, and texture must be uniform. It is also often justified in the plant where a mixture must be delivered to an extruding or pressing operation having absolutely uniform distribution of the active ingredients and of vitreous or organic binder. In preparing these uniform dispersions for an extruding or pressing operation, muller mixing is also of great value because the density often can be controlled to a point where the material can be measured by volume rather than by weight. This method of intimate mixing is often advisable also where a uniform mix of closely associated solid particles must be delivered to a retort for chemical interaction at elevated temperatures.

Whereas muller mixing has the limitation that it is a batch process in an age of continuous processing, detailed study of available raw materials, the physical limitations under which the mixing must be accomplished, and the desired high quality of the end product will often indicate the use of muller mixing for improved quality and greater over-all economy.

Table 1

	Old Slip House Method	Muller-Type Mixing
Maximum capacity/hr.	2700 lb.	5800 lb.
Total hp. required	53	29
Total labor required	4 men	2 men
Production/man/hr.	625 lb.	2940 lb.
Hp./ton of material processed	39.85	10.08
Maintenance	high	very low
Floor space	40 ft. × 80 ft.	37 ft. 4½ in. × 6 ft.

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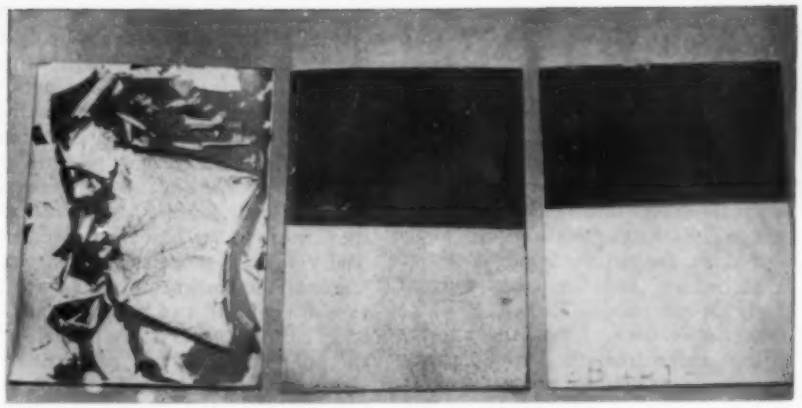


Silicone formulated protective coatings are unaffected by high temperatures, while conventional types peel and crack. Three cold roll steel panels were coated and tested as follows: left panel—coated with an alkyd aluminum finish and subjected to 1000° F. for 2 hours; center panel—bottom half coated with silicone aluminum finish and subjected to 1200° F. for 72 hours; right panel—bottom half coated with silicone aluminum finish and subjected to 1000° F. for 24 hours. The conventionally coated panel cracked and peeled, while the silicone formulated protective coating remained unaffected.—Chemical department, General Electric Co., Pittsfield, Mass.

SILICONES

(*Continued from page* 31)

Processing Details

To produce silicones, the sand or silicon dioxide is mixed with carbon and placed in an electric furnace. The silicon dioxide is reduced to metallic silicon, one of the starting materials in the most widely used method of preparing the silanes—which are the monomers used in the preparation of the polymeric silicones.

Salt is electrolyzed, producing chlorine and sodium hydroxide. The chlorine is then reacted with methane from natural gas to produce methyl chloride, the other major starting material for silane manufacture.

In the direct process for the manufacture of silanes, methyl chloride and silicon are heated at high temperature to produce methylchlorosilanes. These products are then hydrolyzed forming the silicones.

Greatly condensed and simplified, these steps represent the major processes involved. Nothing elaborate in the way of equipment is required but simply a large tank with stirrers heated to 300° C. under moderate pressure. Some manufacturers prefer one large reactor; others a number of smaller ones. There is little choice between the two methods since both are good.

The other important class of silicones is the phenyl silicones, which are made from chlorobenzene (from chlorine and benzene) and silicon. The Grignard process which employs magnesium, methyl chloride, and silicon tetrachloride is used to a lesser extent. Essentially the same type of reactors as described previously are used in production.

Late in 1942, silicones began to be produced on a small scale and the entire production was devoted to making silicone greases. These greases were used in military applications, primarily to prevent the arcing of aircraft spark plugs at high altitudes. From then until 1946, no industrial uses were developed for the silicones because the entire commercial production was taken by the armed forces. At the end of the war the military contracts were canceled and silicone manufacturers suddenly found themselves with no industrial customers. It was fortunate that during this time research had been going on–a research program specifically aimed at eventual industrial products. As a result, there was only a short time lag before silicones began to be sold in large quantities for industrial purposes.

The excellent thermal stability and oxidation resistance of the silicones have been widely publicized and are responsible for their many applications. One of the early uses for silicones was for insulating components in electrical machinery. The silicone resins and rubbers have good insulating characteristics which they are able to retain under extended periods of operations at temperatures as high as 400° F. This property or characteristic has brought the silicones into electrical installations which are operated at high overloads or which must be made as free as possible from electrical failures due to insulation breakdown.

Silicones in Protective Coating Field

Silicones have found specialty uses in the protective coating field because of their good thermal stability and oxidation resistance. These materials have been used at operating temperatures as high as 500° F. without failure; this temperature is about 200° higher than the temperature favorable for most organic protective coating materials. Items, such as space heaters, exhaust manifolds, and heat-exchanger equipment have been protected by silicone paints and varnishes.

GASKETING

The silicone rubbers have been extensively employed in gasketing. The property of low compression set is the one which interests the gasket users. Low compression set means that if the material is subjected to pressure for extended periods of time and then the pressure is released, the material bounces back to its original shape. This is quite important because it assures that there is a positive pressure sealing the system all the time and that the gasket is not likely to leak as the operation is continued. Silicone rubber is exceptionally good for high-temperature gasketing and is finding more and more of a market in this field. Silicone rubbers also have good low-temperature characteristics which means that they retain their flexibility, tensile strength, and resiliency at low temperatures. Such qualities render them important as gasketing materials for high-altitude operations or operations in the Arctic and Antarctic regions.

Surface Characteristics of Silicones

ANTIFOAMING MATERIAL

The surface properties of the silicones have led to many outstanding purposes, one being as antifoaming materials. A type of silicone antifoamer is well employed in aqueous systems in such industries as the paper industry, in brewing, and in food technology. The addition of small amounts of this antifoamer to materials in process reduces the amount of foaming and thus increases the overall manufacturing capacity of a unit. In oil systems silicones play their part in such processes as resin and varnish manufacture, petroleum processing, synthetic rubber latices, and asphalt processing. In these antifoam applications, silicones are more than able to hold their own competitively on an economic basis in spite of their high price. The reason for this is the fact that the silicones are effective in extremely small concentrations so that a little bit of silicone does a job equivalent to a relatively large amount of other known antifoam agents.

RELEASE AGENTS

Another function for silicones which depends upon their surface characteristics is that of release agents. One of the earliest commercial uses for silicones was as a rubber mold-release agent in the manufacture of molded rubber products. The silicones worked exceptionally well with synthetic rubber tires and have since been adapted so that they are practical mold release agents for all kinds of tires–natural and synthetic. The shell-molding process for making precision castings also employs the silicones as parting agents. In this application, the silicones are sprayed onto the completed mold, the part is then cast, and the silicone release properties enable the mold to be removed without causing any imperfections and leaving a shiny, smooth precision surface on the molded

(*Continued on page* 36B)

SILICONES

(*Continued from page 36A*)

part. A third release agent use for silicones has been in the baking industry. In this application new bread pans are coated with silicone resins and the resin is baked on. From this time and for approximately 100 to 200 cycles, no lard or grease enters into the baking operation. The dough mixture is simply poured into the pan, the baking operation is carried on, and the loaves fall out freely at the end. This has led to cleaner operations of the bakery owing to less smoke from the burning grease and to a more uniform product. So far, the silicones have not been universally adapted to the cooking of cakes and baking products which contain relatively large amounts of sugar.

WATER REPELLENTS

Another use for silicones which is based on their surface properties is that of water repellents. There are three different types of silicone masonry water repellents: one a highly polymerized resin solution in organic solvents, another a water soluble silicone, and still another which is a partially polymerized material again in hydrocarbon or alcoholic solvents. These masonry water repellents are applied by spraying on masonry surfaces. The resin solution must be applied to a dry masonry surface, but the water soluble and partially polymerized silicones may be applied either to wet or dry masonry surfaces. This treatment makes the surface water repellent and prevents moisture from entering the interior of the masonry and subsequently from bleaching out salts and causing blooming or in the winter time from freezing and causing spalling. Also, the treatment does not clog the pores of the masonry as do some other waterproofing materials. The silicones allow the masonry surface to breathe which is an important item.

Textiles have also been rendered water repellent by treatment with silicone fluids. This application has a large potential market but at the present time it is somewhat limited because a special silicone material, required for the textile water repellent, is not available in large quantities. The performance characteristics of the silicone-treated textiles are good and again, in spite of the high cost of the silicones, the economics is such that the silicones are competitive in this field. A related application is the silicone treatment of leather to make it water repellent. The leather is made water repellent without actually closing the pores and allows the leather to breathe. This application is newer and has not found so large a use as the masonry water repellents or the textile water repellents but will probably develop with time.

Another general application for silicones, which is widely known to the general public, is in the field of polishes. Practically all automotive polishes now contain silicones in varying amounts. It is possible to use a silicone fluid without any wax to polish automobile surfaces. However, experience has indicated that the mixture of silicones with waxes is a better over-all product both from a performance and an economic standpoint. The two main properties which enable silicones to work in this field are the ease of application of the polish and the long lasting effect. It is possible now to apply a silicone-wax combination in about an hour which will do a job equivalent to the old hard wax applications which took all day to apply and rub down. Furniture polishes also contain silicones for the same reasons. Again, many of the commercial furniture polishes on the market today contain silicones in varying amounts.

The inertness of silicones has been capitalized on in several different ways. Chemically speaking silicones are not inert to strong acids or strong alkalis but are inert in neutral systems. One of the places in which this inertness is of value is in electrical machinery which is impregnated with a silicone varnish, and, since the varnish is inert to water, it is possible to immerse completely electric motors in water and still have them operate without failure as long as the water is not strongly acid or strongly alkaline. Such a protective coating will last for an indefinite period of time. It has been found also that silicone paints do not become yellow even at high temperatures of operations or during long outdoor weathering exposures. The masonry water repellents are another example where the water repellency is one factor promoting the use of silicones, but the inertness of the material to the atmosphere, and, hence their long life is also a part of the general picture.

Silicones as Lubricants

One of the first properties noticed about the silicones was that they have extremely low temperature-viscosity coefficients. This technical term simply means that the viscosity of the silicone fluids changes little with temperature as compared to ordinary fluids. This property has led to the use of the silicones in hydraulic systems where operation at both high and low temperatures is desired, in lubricants, and in damping operations. Silicones are not particularly good lubricants when it comes to sliding metal-to-metal friction but they are satisfactory lubricants for rolling metal-to-metal friction and are excellent lubricants for plastics, fiber gears, and rubber products. Some of the damping uses include shock absorbers, dash pots, delicate instruments, and torsional vibration damping systems.

Top, symposium on the Professional Attitude; 2, western party, note: Spanish moss; 3, enjoying the luxurious Shamrock pool in 86° heat; l. to r. front, F. C. Stults, W. E. Lobo, G. Klein, back, E. F. Jennings, C. V. Foster, Leo Friend, D. A. Lobo; bottom, W. B. Franklin, general co-chairman, Mrs. Franklin, Mrs. W. W. Blake, Mr. Blake, chairman Hotel and Meeting Rooms Committee.

WESTERN PARTY

HOUSTON

ATTENDANCE largest for national meetings—1300 registered . . .

DEVELOP a stronger professional attitude—then many problems and dissatisfactions will resolve themselves, implied Sunday afternoon panel . . .

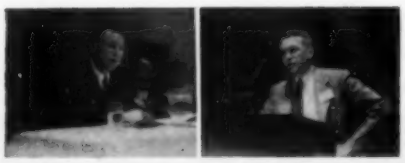
EDUCATION of chemical engineers in future charted by symposium group . . . some chemical engineers will have to be scientists as well as engineers to meet unprecedented future needs, according to some leaders . . .

RADIO broadcast by leading members of profession told of vast contribution chemical engineering has made to our higher standard of living . . .

PRESIDENT Dodge advised students to start out with a strong attitude of professional responsibility . . .

SOCIAL side enhanced by Texans' hospitality . . . good weather . . . and Shamrock Hotel luxury . . . Chuck Wagon dinner in beautiful grove under a Texas moon an unforgettable event . . .

Left: The luxurious Shamrock; center: President B. F. Dodge addressing student luncheon; right: Miss Joy Mdlinka interviewing C. G. Kirkbride (right) and J. F. McKetta on how chemical engineering has brought about higher standards of living, 10:30 A.M., May 2, Radio KXYZ.



L. to r.: top, R. P. Dinsmore, E. F. Von Wettberg; bottom, L. P. Scoville, J. H. Rushton, W. A. Cunningham.

If you attended the Houston National Meeting of the Institute, May 1-4, you will probably see your likeness, or at least those of your friends, in the accompanying pictures. If you didn't attend, you missed an opportunity to get to know a grand and progressive group of people—the chemical engineers of Texas.

Legendary in myth and "tall" stories, Texans have proven equally fabulous in real action, and Texan members of the chemical engineering profession are no exception. Together with their fellows throughout the natural gas lands and petroleum country in general, Texas engineers are accustomed to handling throughputs of raw materials large enough to give them their own reasons for talking "large" quantities, real "tall" stories.

At the A.I.Ch.E. meeting in the luxury Shamrock, Texans gathered in numbers with other chemical engineers from all sections of the country on Sunday afternoon to hear panel headed by Ray Dinsmore (Goodyear) deal with the subject "The Professional Attitude"—one which already has received considerable attention (Sunday afternoon symposium, New York Annual Meeting, 1954, plus a series of articles appearing in C.E.P.).

The Dinsmore group at Houston did a memorable job in establishing one fact above all others—many, perhaps most, of the engineers' complaints and feelings of maladjustment will disappear once they are able to develop a truly professional attitude towards employers and, perhaps most important of all, towards themselves.

Art Doolittle, vice-president of the Institute, advised putting desire to serve usefully, and satisfaction arising from occupation, ahead of striving for purely monetary gain.

WESTERN PARTY

(*Continued from page 37*)

Von Wettberg of Dupont called for cultivation of ethics, and a sense of dignity in relations with all employers and associates. To assist in attaining such an atmosphere with employers, Von Wettberg reminded his audience, "the employer can get from no one else what he gets from chemical engineers . . ."

Turning to the creation of young engineers with a truly professional attitude, Henry Rushton (Illinois Institute of Technology) asked the teaching profession to set aside the teaching of facts, at least part of the time, and observe and mold the students' attitudes on the basis of their being human beings capable of a wide range of emotions. We are coming to realize that it is "not what a man has studied, but how it was presented to him . . . ," according to the Professor.

Referring to individuals in industrial management, Rushton called their attention to their role in providing a healthy emotional and educational environment for their young chemical engineers, and cautioned, "many students leave their universities with good professional attitudes—with care, you can keep it alive and growing . . ."

Lauren Scoville, Diamond Alkali, had some advice for every management employing chemical engineers. Outstanding was his belief that the chemical engineer will perform best only if he is taken into full confidence and given a broad panorama of background information pertaining to the project on which he is employed. "As managements realize that engineers are professionally honest, much of the old time top-level secrecy will gradually disappear," he stated. Having engineers perform functions as complex and as non-clerical as possible is only common sense and good economics, according to Scoville. One last bit of advice offered was for the direct supervisor to have at least one annual talk with the engineer about his progress. Twofold advantage was claimed for this: Clearing the air regarding feelings in either direction, and leaving the employee with the secure feeling of knowing where he stands.

Comparing the professional engineer's fervor with that of the minister of the gospel, the doctor, lawyer or other dedicated individuals, Ray Dinsmore held out strong hope to young engineers that real professionalism is within grasp—even without being self employed. "There is a misconception that a professional engineer cannot engage in work of high professional standards when taking part in a group venture with others for a common employer," warned Dinsmore, adding that this is often only rationalization.

Dinsmore's full remarks appear elsewhere in this issue of C.E.P.

(More on Houston Meeting in June C.E.P.)

DODGE HUNG!

Unaware of fate, President Barney Dodge allows arrest without a protest.

Trial over, hanging begins. Judge Roy Bean (J. F. McKetta) looks smugly just.

Judge Bean looks proud, while Sheriff takes no chances as life ebbs away.

The sad, sad end—Judge Bean draws self up into righteous pose; Sheriff worries as to whether Barney stretched the rope.

Skit over, Barney is rewarded for his good sportsmanship by being made honorary member of Harris County Sheriff's Mounted Posse by Bernard Paul, group's president.

INDUSTRIAL NEWS

Automatic—In The Future But Not Yet

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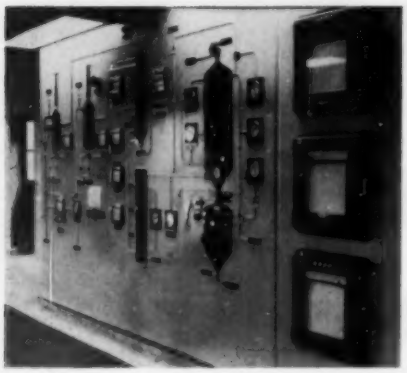
PIONEER JOB FOR INFRA-RED

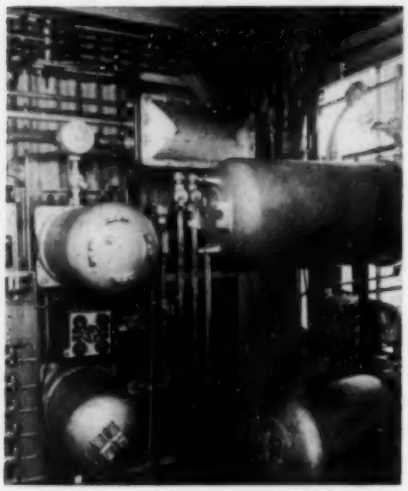
Infra-Red analyzers do pioneer job at Cyanamid's new acrylonitrile and ammonia plant.

Analytical "watch-dogs" increase efficiency and yield by determining stream composition.



Above: Control panel of Fortier acetylene unit. Recorders (r.) show concentration of gas under analysis.

Below: Infra-red Tri-Non analyzers installed in Fortier production stream. Each bank serves four burners.



Operating continuously to detect stream component concentration changes to an accuracy as great as 1 ppm, Perkin-Elmer's Tri-Non analyzers are pioneering as the first such continuous analytical controls designed right into the process stream of a plant as large as Cyanamid's new acrylonitrile and ammonia plant at Fortier, La.

Unveiling the major analytical control development, L. Davenport, executive-v.p. of Perkin-Elmer, T. P. Forbath, Chemical Construction Corp., and E. L. Carpenter, Cyanamid, emphasized the closer control possible with infra-red analyzers, with resulting increased efficiency and yield.

The Sachsse acetylene process used at Fortier partially burns natural gas in the presence of oxygen to make acetylene raw material which is later reacted with HCN to make acrylonitrile. The close control required in this process to achieve best results is gained by using the analyzers to monitor the process stream continuously at critical points.

To do this job, Davenport showed, infra-red energy is beamed through combustion gases coming from the natural gas burners. Molecular components absorb certain parts of the infra-red spectra and are identified by "blind spots" picked up by the analyzers. The device then transmits the information to a recorder where a plant operator reads it and makes the necessary adjustments —all this in a matter of minutes. By conventional analytical methods, hours are required for the same analysis—a time lag that can mean money in lost efficiency and impure product.

Automatic—In The Future But Not Yet

A big step toward the automatic plant, the method is not yet fully automatic. It requires a highly trained process technologist to interpret the data and make the necessary adjustment in methane-oxygen feed ratio. Eventually, a computer will do this job, but not likely in the near future. Reasons: Need to develop relationship between computer function and dynamics of burner operation (knowing that to restore correct operation is presently a "human" job). After being technically feasible, time will be needed for operating personnel to learn to trust the analyzers–computer arrangement.

Producing both acetylene and hydrogen, in varying quantities on demand, monitors must analyze both the furnace process gas and the off-gas (the latter containing no more than 0.3% acetylene for safety of compression). Other Tri-Non's analyze carbon dioxide removal in the purification tower. Still another monitors the ammonia unit.

Process Shift

Originally devised to use the ethylene oxide "indirect" route to acrylonitrile, the Fortier plant is expected to be completely on the direct reaction between acetylene and HCN very soon. While the ethylene oxide process has produced a purer grade of acrylonitrile in practice, it has the problem of non-productive expense in hydration and then dehydration. Now that the direct process, originally devised by the Germans, has eliminated the disadvantage of 3-4% vinyl chloride by-product, it is being adopted by Cyanamid. Here it's critical nature called for the new infra-red analyzers.

In addition to acrylonitrile and ammonia, the Fortier plant expects to produce methyl styrene (used in plastics), acrylamid, and "products of other hydrogenation processes." Cyanamid will directly enter into synthetic fiber production upon completion of facilities, based on the Fortier-produced acrylonitrile, now being sold. The company is already studying treatment of cotton with acrylonitrile.

A new plant to supply polyethylene producers with **dispersions of pigments and carbon black** was recently opened at Orange, Texas, by Acheson Dispersed Pigments (Texas) Co., a subsidiary of Acheson Industries.

Selection of the sight was based on the growing importance of the area as a major polyethylene producing section.

Construction of a **new $4 million petroleum cracking catalysts plant** by Davison Chemical Division of W. R. Grace is expected to start in April.

The plant, which will go on stream in about a year, will manufacture the microspheroidal form of synthetic petroleum cracking catalyst. Raw materials for process are sulfuric, ammonia, sodium silicate, and aluminum hydrate.

Capable of turning out more than a trainload of sulfuric acid a week, a **new contact unit** of DuPont's Grasselli Chemicals Dept. is the **world's largest single unit.**

Recently brought into commercial production, the unit is at Grasseli's East Chicago Works. Begun last August, it is a major step in Grasseli's long-range modernization program to meet the rapidly rising demands for sulfuric.

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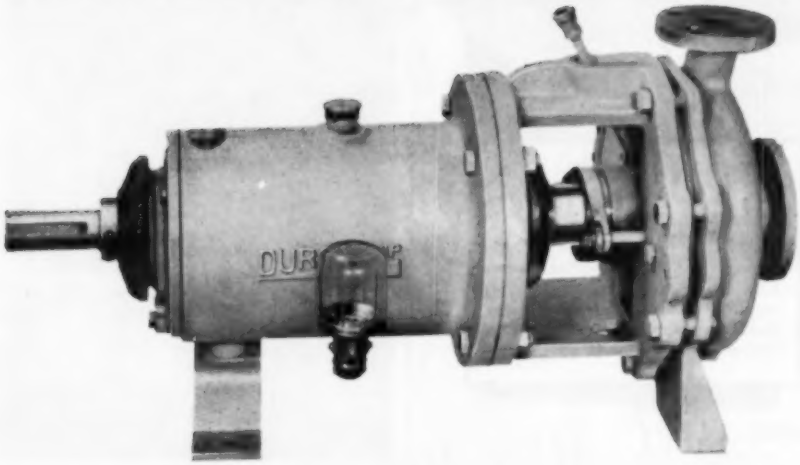
NEW for heavy duty corrosion service



Series H DURCOPUMPS are all new, heavy duty chemical pumps. With a large, rugged shaft, heavy bearings, open or closed impeller and new features of adaptability, these pumps provide long, dependable pumping life with easy, low-cost maintenance. Designed for high heads and low capacities as well as for routine conditions, Series H Durcopumps can provide the answer to your tough pumping problems.

NEW for easy modification and minimum spare parts inventory

only 3 BEARING HOUSINGS for the complete range of pump sizes

The entire range of new Series H Durcopumps is accommodated by just three bearing housings and suitable adaptors. This unique feature coupled with the availability of eleven standard Durco alloys make the Series H DURCOPUMPS the most versatile chemical pumps ever developed.

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A simple, economical and efficient method of restoring contaminated lubricating and sealing oil to the full value of new oil. HILCO Oil Reclaimers are used for the purification of vacuum pump oil in conjunction with the manufacture of transformers, condensers, capacitors, drugs, vitamin concentrates, radio tubes and light bulbs, essential oils, optical lenses, refrigeration compressors, titanium and many other products. A HILCO will produce and maintain oil free of all solids, sludge, acid, moisture, solvents, and dissolved gasses and restore viscosity, dielectric strength and other specifications to new oil value.

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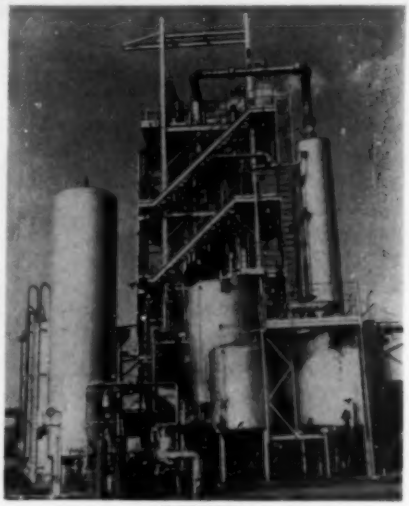
INDUSTRIAL NEWS

A revamped process for producing maleic anhydride has been installed at Reichhold Chemical's New Jersey plant.

The changes, mapped out and built by Reichhold and Scientific Design Co., New York, are expected to produce greater yields of maleic. If it works out as expected, Reichhold plans to expand the plant to more than double present capacity.



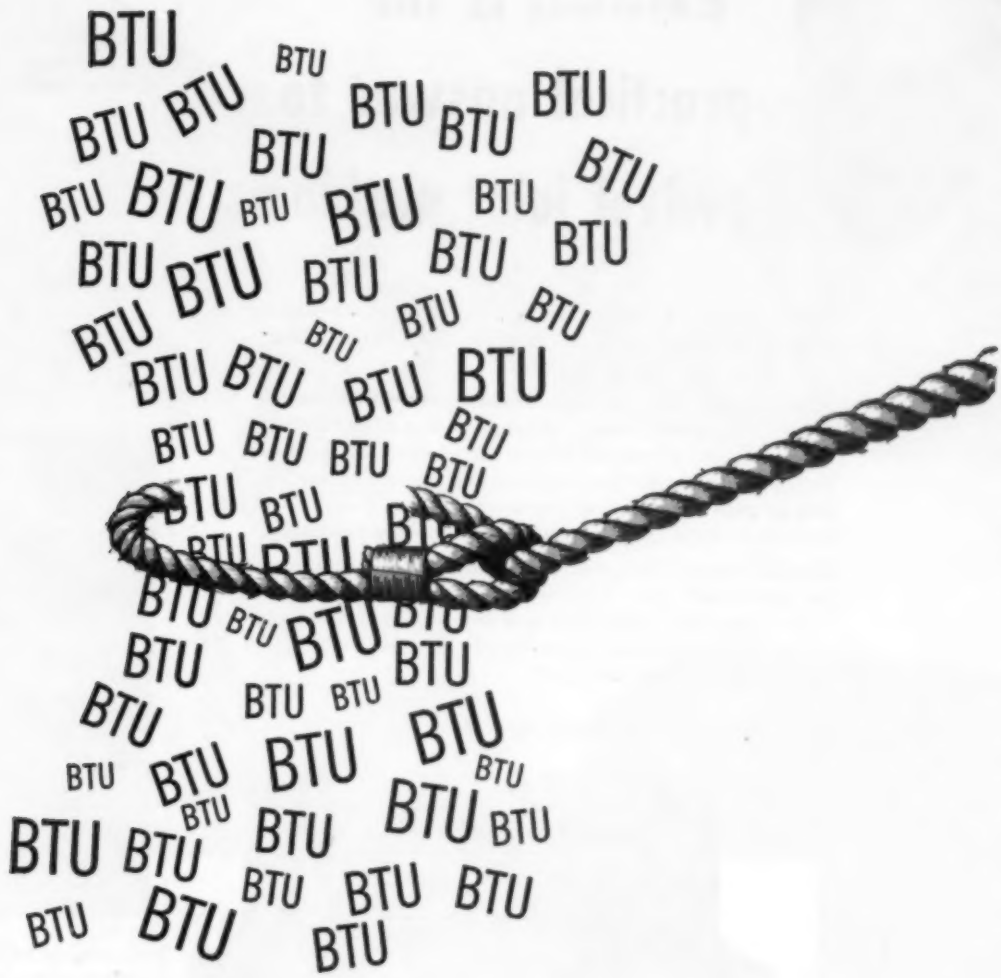
New research laboratory for basic, exploratory work is being built by Union Carbide for its National Carbon Division. The laboratory, located in Parma, Ohio, will concentrate on fundamental work without regard to immediate practical results.

Much of the new lab's work will be done in the field of solid state physics, on metallic and non-metallic compounds of carbon, and on analogous compounds such as inter-metallics and semi-conductors.

Expansion of Stauffer Chemical's Bayonne, N. J., insecticides plant includes installation of additional units to increase the air milling capacity of the plant as well as a modern unit for formulating liquid insecticides.

Forty-ton per day liquid mixed fertilizer plant will be constructed in the immediate future by Curry Chemical Co., wholly-owned subsidiary of Phillips Petroleum.

The new plant, to be built at Scottsbluff, Nebr., where Curry has extensive dry-mixing facilities, will be equipped to produce liquid fertilizers containing the basic plant foods nitrogen and phosphate, along with potash when desired. Primarily, the plant is planned to be a development facility for providing fundamental information to interested distributors and users.



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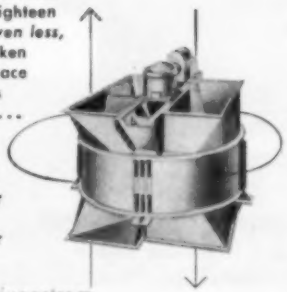
In fuel savings alone, most refiners write off the cost of the Ljungstrom installation in twelve to eighteen months. This time is cut to *nine months and even less*, when the other Ljungstrom advantages are taken into account — permits more economical furnace design, with no need for convection surfaces . . . burns many fuels you used to throw away . . . results in consistently higher through-put . . . boosts product quality . . . and minimizes slag.

For more complete details on what the Ljungstrom Air Preheater can do for you . . . for an analysis of the heat-recovery benefits attainable in fuel burning equipment — call or write The Air Preheater Corporation.



Wherever You Burn Fuel, You Need Ljungstrom

The Ljungstrom operates on the continuous regenerative counterflow principle. The heat transfer surfaces in the rotor act as heat accumulators. As the rotor revolves, the heat is transferred from the waste gases to the incoming cold air.

How much fuel do your process units burn *just to keep the stacks hot?* It takes precious BTU's to keep them as hot as they are . . . BTU's that, if recaptured, would be working for you — instead of costing you money.

With the Ljungstrom, much waste heat is recovered from exit gases, transferred to incoming combustion air and funneled back into the furnace. How much fuel does this save? You get an idea when you consider that for every 45-50°F of preheat, your fuel bill drops 1% — and Ljungstrom Air Preheaters now in use preheat air to over 1,000°F.

That's why a Ljungstrom saves you up to 20% of your fuel costs — *one barrel in every five.* In fact, one midwestern refiner reports $74,200 saved in fuel in one year. And after he subtracted the Ljungstrom operating cost, he still wound up the year $64,800 ahead.

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When you buy a swing joint you buy two main benefits: Ease of turning and a good method of packing against leakage. Emsco offers you both.

With Emsco, load on the ball bearings is parallel to the lines of force and directly through center of the balls, thus reducing frictional torque for free turning under heavy loads. A patented packing and packing chamber design with easy take-up feature provides effective sealing against leakage; prolongs life of the joint indefinitely.

Emsco Swivel Fittings are manufactured in popular sizes for practically every type of service; from high vacuum to pressures of 15,000 p.s.i., and from sub-zero temperatures to 750° F. Simply tell us your application and type of end connections required.

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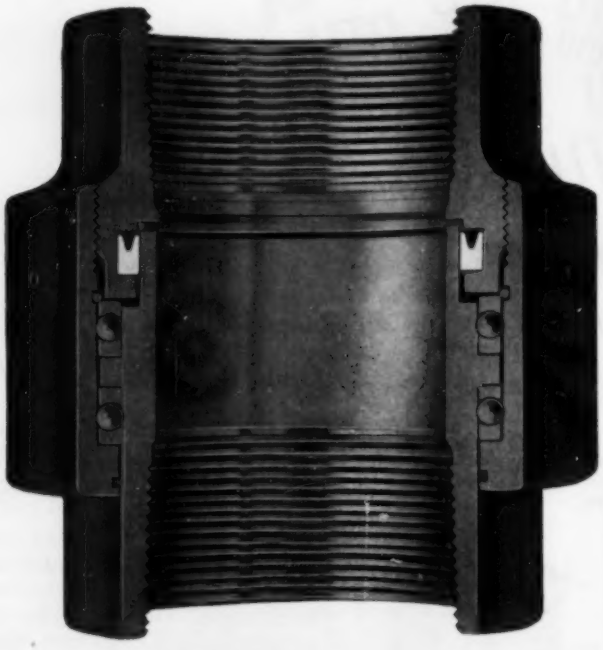
THRUST BEARINGS FOR THRUST LOADS



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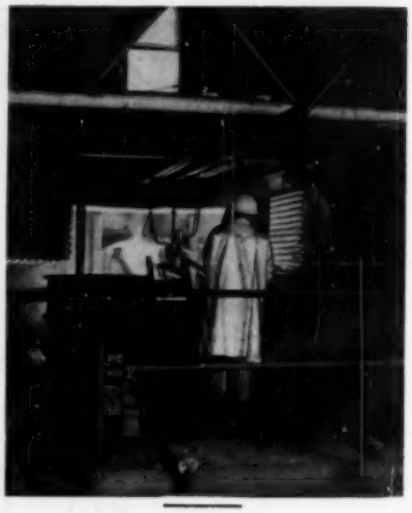
INDUSTRIAL NEWS

Ninety-eight per cent pure metallic silicon is being produced in **Dow's new electric smelting furnace** at Midland, Mich.

Capable of reaching and maintaining 3100 degrees F., the reduction temperature of silicon, the furnace consumes as much electric power in one hour as the average home uses in three years.

Heated by an arc which flashes from three carbon electrodes, the furnace is energized with low voltage 3-phase power going to each electrode in turn and producing an arc which sweeps through the charge in a rotary motion.



Start-up of **Magnolia Petroleum's giant (250 ft. high) Thermofor Catalytic Reforming unit** on March 15 brought on stream the first unit of its kind in the Southwest, second in the world. Designed to reform naphthas and low-octane gasolines, through catalyst-aided molecular change, into very high octane fuels, the new unit has a 19,000 bbl./day capacity.

Only other unit of this type is at General Petroleum's Torrance, Cal., refinery.

New Canadian plant for Pfizer is in the planning stage. End result will be multi-million dollar installation to manufacture pharmaceuticals, including the company's anti-biotics.

A $2.5 million chlorine and caustic plant ten miles north of Haifa in Israel will begin production toward the end of 1955. With close to $1 million of capital supplied by American investors, the new plant is expected to give a big boost to Israel's expanding agriculture.

Maximum daily output will include 8.3 tons caustic, 7.5 tons chlorine, 3 tons hydrochloric acid (33%), and 5 tons benzene hexachloride (13% gamma).

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DeMISTERS

Assure clean separation between vapor and liquid

Yorkmesh Demisters—by effecting clean separation between vapor and liquid—improve the performance and increase the throughput capacity of any process vessel handling both liquid and vapor phase materials.

Yorkmesh Demisters are knitted wire mesh pads, available in a variety of types, sizes and materials. The unique fine wire construction provides flexibility, resiliency, light weight, high structural strength and extensive surface area. These Demisters are supplied to the exact size and shape required and are usually furnished mounted on light weight open type support grids. Installation is simple in both new and existing equipment.

Vapor-liquid separation efficiency with Yorkmesh Demisters in process vessels is always very high, usually in excess of 99.9%. Where Yorkmesh Demisters are installed in evaporators, distillation columns, gas filters and absorbers, liquid entrainment is substantially completely eliminated.

Pressure drop is so low that it is nearly always negligible. At atmospheric pressure vapor velocities between 2 and 12 ft./sec. are recommended. Under vacuum, depending on conditions, vapor velocities of 30 ft./sec. and higher are possible.

Yorkmesh Demisters are fabricated in a wide variety of materials, densities and wire mesh constructions which are selected to give best performance for the particular operating conditions.

Yorkmesh Demisters are available for prompt delivery in the following materials:

Types 304, 316, 317, 410 and 430 stainless steel
Monel, nickel, Inconel
Aluminum (56-S wire alloy)
Low carbon steel, copper, brass
Also available in Carpenter 20 stainless,
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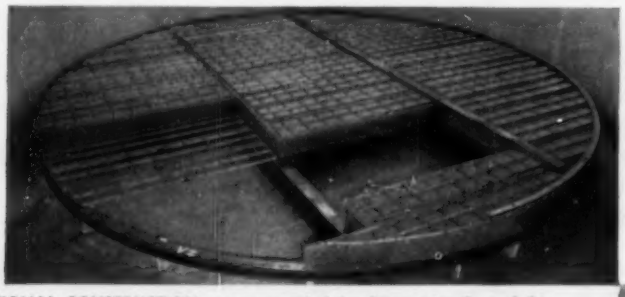
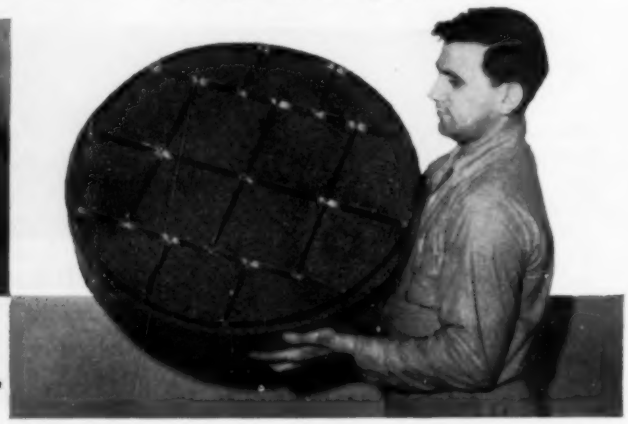
The wide experience of the Otto H. York Co., Inc. with thousands of demisters in service provides a sound basis for recommendations that assure the most economical and efficient type of demister for each application. Call on York to solve your problems in vapor-liquid separation.

Complete catalog and list of technical literature (TL54) free on request.



SECTIONAL CONSTRUCTION—recommended for large vessels and for all applications requiring installations through a manhole.



ONE-PIECE CONSTRUCTION—recommended when installation can be made through end of vessel.

Increase throughput capacity!
Improve process efficiency!
Improve overhead quality!
Reduce contamination!
Stop costly liquid loss!

Yorkmesh Demisters are being used successfully in all types of process vessels handling both liquid and vapor phase materials. Some typical examples—

VACUUM TOWERS:
To increase throughput and improve quality of gas oil by separating entrained asphalt. To decrease metals contamination of gas oil. To improve quality of lube distillates.

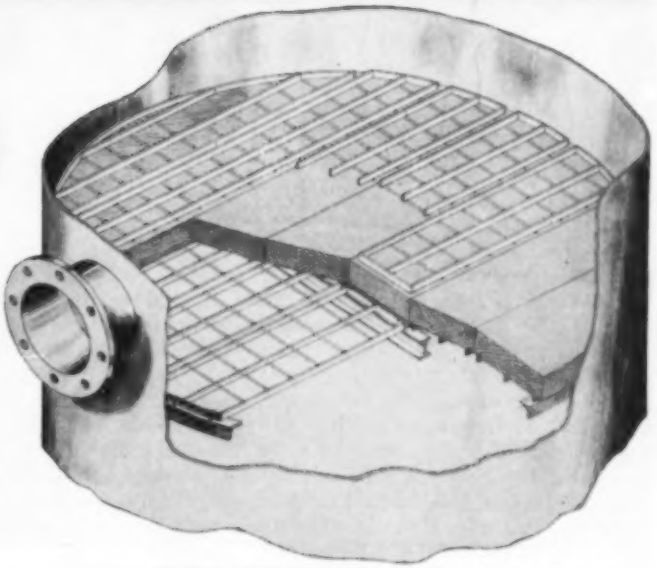
DISTILLATION:
To remove entrained liquid fatty acids from fatty acid vapors. To improve quality of organic product while increasing production. To eliminate glycerin losses.

FLASH TOWERS:
To recover clean naphtha from asphalt solutions. To separate propane from asphalt.

ABSORBERS:
To remove absorption oil from natural gas. To prevent loss of glycol and amine solutions.

EVAPORATORS:
To produce high purity steam from concentrated caustic soda solutions. To stop entrainment losses from valuable fluoride solution.

KNOCK-OUT DRUMS:
To remove water and oil from air. To remove fatty acids from superheated steam. To reduce compressor maintenance by removing liquid entrainment from the gas.



SECTIONAL TYPE DEMISTER IN PLACE—cutaway view.

STEAM DRUMS:
To eliminate liquid entrainment in order to produce high quality, high purity steam.

GAS FILTERS:
To clean manufactured gas. To separate sulfuric acid and solids from chlorine gas.

COMPRESSORS:
To separate entrained liquids from compressor discharge gasses.

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To separate water from natural gas. To eliminate mist from flue gas. To remove natural gasoline from natural gas.

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the CHEMICAL ENGINEER and the PUBLIC

R. P. Dinsmore

Goodyear Tire & Rubber Company, Akron, Ohio

When we speak of "the public" we are talking about the whole body of people in our society, of which each one of us is a member. This reference is seldom actually made to the entire body of people, however, but only to that segment of it which composes the human environment for an individual when he does certain things of a particular nature, and which fall into a particular category. For a single individual the public may be composed of different people at different times as he assumes different roles or as his actions from time to time are chiefly directed toward one objective, then another.

To give a few examples: to the orator the public comprises people within the sound of his voice, whether that be limited to his immediate vicinity or be extended by radio, television, or otherwise to distant places. To the politician acting in his official capacity, the public is much more general but is still limited to those people who can influence his political career. To the storekeeper the public is made up of those people who are his current, or potential, customers and so on throughout our social existence. Each person has his own individual publics, such as those groups of people which respond to his behavior as a member of the community, a club, a church, a scientific organization, a member of the Armed Forces, etc.

"The Public"—More Specifically

Since the term "the public" is thus obviously somewhat indefinite, and yet is partly responsive to the activity under consideration, we might define the expression in relation to the professional engineer, keeping in mind that any individual in the various facets of his normal existence influences and is influenced by somewhat different groups, and that the sum total of these group reactions has an important bearing on the specialized activity that he may select for his career. Putting aside these influences as matters of common knowledge we shall consider here only the people who are influenced by special, and in this case, professional activity.

The professional engineer may come into contact with the public in the course of carrying out managerial, consulting, or research work for public institutions. He may also be called upon to give expert testimony in court actions, or to speak for or against proposed projects of a nature that need his specialized knowledge and training. He may be engaged in a consulting business where his professional services are required by individuals or groups whose activities reach into many fields of public interest. He may wish to present his views in written form through publications that reach broad segments or highly specialized areas of the population.

The *really* professional engineer is dedicated to the improvement and social acceptance of his profession quite the same as the professional minister is dedicated to the promotion and acceptance of his religious doctrines. He therefore feels the urgency of seeking out and supporting better and more universal ways of training young men with talent to become good engineers with proper ideals and appreciation of the social standing and importance of their profession. He may feel called upon to engage with others in the raising of funds to provide better training for engineers. He may wish to influence nonengineering members of his community to adopt a more enlightened view of the engineer and his profession.

One realizes that there are numerous other ways in which an engineer may come into contact with the public in the pursuit of his professional activities. It becomes evident that in each instance the public is a somewhat different group of people, varying perhaps both in character and numbers, but representing individually and collectively a vital source of appraisal or as we loosely call it public opinion.

The very necessity for entering into so roundabout an explanation of the professional engineer's public makes it evident that any attempt to define within narrow limits the course of action which should be adopted by a professional engineer dealing with the public in the course of his duties would be doomed to failure.

A Misconception of the Professional Role

I have been greatly surprised in talking with numerous engineers about what might be accepted as high professional standards, to find that there is a considerable body of opinion that neither professional standards nor public acceptance for the engineer can be rated as high as those for the doctor, lawyer, or minister because the engineer does not ordinarily act as a self-controlled unit to the extent that members of the learned professions do. To me it is exactly the same thing as saying that only those

(*Continued on page* 50)

knowledge which is not only of significance to social progress, but also

and perhaps it may surprise many cynical objectors to know that by and large

Meet the man you can call with confidence to solve your thermal insulation problems

To insulate outdoor tanks with complete weather protection, these skilled J-M applicators follow a specification developed by Johns-Manville. Here they are fastening J-M Asbestocite* Sheets over J-M Zerolite* Insulation. J-M 85% Magnesia Insulation is also widely used for this type of equipment

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MATERIALS · ENGINEERING · APPLICATION

INDUSTRIAL NEWS

Specify

(*Continued from page 48*)

who live in isolated spots can be expected to observe monogamy, whereas the people who live in communities must necessarily be polygamists. There seems to be a misconception to the effect that a professional man cannot regulate his professional conduct or conduct himself according to high professional standards if he works with a group of people who have the same employer. This seems to be a rationalization for inability or unwillingness to cooperate with others in an effort to produce the desired results. If this view were to be commonly accepted, we might as well abandon all hope of receiving for our profession the public recognition of the dignity and worth which, in my opinion, it undoubtedly deserves. Undoubtedly there is confusion in the minds of many employers, both large and small, who utilize the services of engineers, in the minds of educators whose duty it is to start the engineers upon their professional careers, and in the minds of engineers themselves. A cynical viewpoint is held that is too often supported by facts, to wit, that the sole objective of the engineer is to obtain for himself the largest possible income in the shortest possible time and with it whatever social prestige such an income can purchase. To the extent that such an attitude prevails among any group of engineers, it will be recognized and receive the normal reaction from the employer and the public.

If I were addressing these remarks to Science teachers in public high schools, I would feel considerably more insecure in my plea for consistently high professional standards than I do when directing my remarks to the professional engineer. In the first instance the salary scale is woefully inadequate, in almost all instances. In the second case, however, the general standard is reasonably high and opportunities are plentiful for improvement if the individual engineer is competent, aggressive, and cooperative. Therefore, we are not suggesting to the professional engineer that he make the choice between high ideals and starvation. We are suggesting that he re-examine his motives and his long-term objectives and answer the question whether adoption of the dollar sign for the primary objective will not only degrade his profession, but also deprive him of the satisfaction which can come only from the competent fulfillment of his professional obligations.

It has been said in various ways no doubt that a trained and experienced professional engineer has a specialized knowledge which is not only of significance to social progress, but also places the lay public, including a considerable proportion of employers, in a position where they must rely upon the integrity of the engineer for their judgment on what he has accomplished or may accomplish under specified conditions. This is an obligation from which no professional engineer can escape except by renouncing his profession and making it clear to all and sundry that he has entered some other endeavor, and will neither claim nor accept payment or recognition which depends upon engineering standards.

Public Attitudes Towards Ethics

Much discussion has been going on among car-owners in the past 10 or 15 years about the difficulty in getting honest and reliable mechanics for repair work. Many such owners have discovered from time to time that they have been charged for work that was not done, for parts that were never replaced, or overcharged for time that was spent in the repair. Thus, a rather general suspicion of motor-car repair people has arisen. This suspicion has created irritation which has been greater in proportion to the individual's lack of knowledge of the inner workings of his automobile. This is a simple illustration of betrayal of trust where the skilled mechanic takes advantage of the ignorant car-owner to defraud him of his money. The engineer likewise perpetrates a fraud upon those with whom he deals professionally if he does not do his work according to the best of his knowledge and ability, or if he accepts work under the pretext that he is competent to do it when he is not. To the extent that engineers relax from high professional standards they cast discredit upon themselves and upon their profession because they create a general distrust of almost all engineers. It needs no complicated code of ethics to make the obligation of an engineer crystal clear in this respect, and, as previously stated, such obligations cannot be avoided.

The public has a right to expect not only the honest, competent application of engineering skill and judgment, but also that such application represents the output of the individual, unbiased and uninfluenced by others, at least to the extent that human beings are capable of subjective viewpoints.

Thousands of engineers have demonstrated that they can adopt and maintain high professional standards in whatever capacity they may perform their services. They have shown that when there is a choice between personal gain and the standards of their profession, they have chosen to adhere to those standards, and perhaps it may surprise many cynical objectors to know that by and large these men have proved themselves to be the most outstandingly successful in their fields of endeavor throughout the engineering fraternity.

Public's Dependence on Engineers

When the United States first became an independent nation, there was practically no object which was in common use unless it may have been a watch or a clock which was not thoroughly understood in all its parts and mechanism by the ordinary layman. As a matter of fact, to a great extent, people fashioned their own tools and implements, even making their own gunpowder and soap. In those days there were few mechanical mysteries, and an artisan was universally judged by the excellence of his work. Today, there is scarcely a labor-saving device in use in the household which the average layman can understand, much less reproduce with his own hands. Yet what we have today is probably nothing in complexity as compared to what the next generation will have at its command. More and more the lay public will depend upon the integrity, honesty, and ability of the engineer and the scientist, not only to produce the things which create higher and higher standards of living, but also to maintain an order of existence (and I am not being political here) which will not collapse through a sudden failure of power or water supply. The engineer is standing at the crossroads—he will either choose for himself standards of professional action that securely establish him in the confidence of the public, or he will be supplanted by a group of engineering and scientific professional people with standards of competence and integrity so high that they will dominate the whole social scene because the routine engineer and scientist will be utterly unable to break the intellectual barrier that separates them.

Not Wanted: A Scientific Autocracy

I would contemplate the movement toward such an inner circle with great misgivings. For a time this necessarily existed among the atomic scientists, and many an outsider who has contemplated this group and has lately gained some conception of the tremendous advances it made in both theory and application, will understand what I mean when I refer to the ultrabrilliant few taking up the obligations of the many. This is a type of scientific autocracy which would accord ill with our democratic habits but which circumstances may yet force upon us if we fail fully to meet our professional obligations.

Presented at A.I.Ch.E., Houston meeting.

INDUSTRIAL NEWS

Claimed to be **first unit in the world capable of producing synthetic methyl mercaptan in multi-million pound quantities,** a new mercaptan synthesis plant has just been completed by Pan American Refining, a subsidiary of American Oil, at Texas City, Texas.

When operating at full capacity, the plant will produce five million pounds of methyl mercaptan a year. Initial production will be confined to high purity methyl mercaptan for use as an intermediate in organic synthesis, although the plant has been designed to produce other mercaptans, such as ethyl and propyl, if desired.

Engineering contractor for Union Oil of California's **new shale demonstration plant** in Colorado will be Stearns-Rogers Manufacturing Co. of Denver.

The demonstration plant, which will include a 1000-ton/day shale retort, is part of Union's $5 million research program to evaluate the profitability of developing the 50,000 acres of shale land it owns in Colorado.

Synthetic fabric without spinning or weaving is the goal of experiments now underway at St. Regis Paper Company. St. Regis has been working for sometime on these experiments to attempt the application of paper-making principles to the production of fabric from DuPont's orlon, dacron, and nylon.

Objective is to produce a fabric from the synthetic fibers exactly as paper is made from wood fibers, without spinning or weaving. Such a fabric would be competitive with silk, wool and cotton.

Milton Roy Company is planning to build **a new plant** near St. Petersburg, Fla., to expand its production of controlled volume pumps and complete chemical feed systems.

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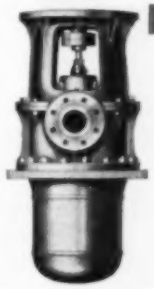
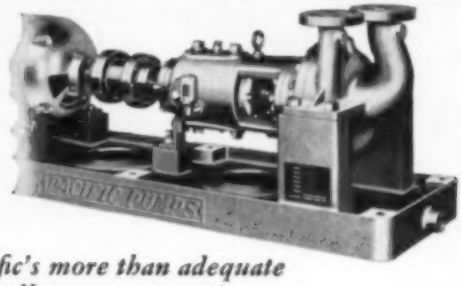
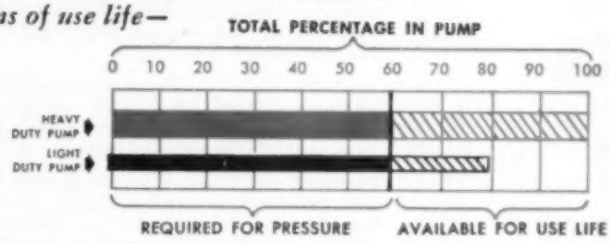
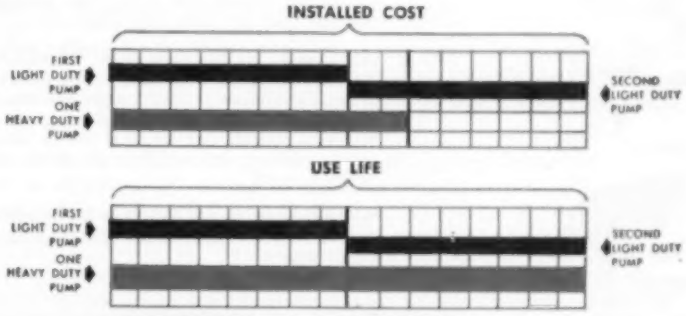




Here is what Pacific's more than adequate corrosion-erosion allowance means in terms of use life—


TOTAL PERCENTAGE IN PUMP
0 10 20 30 40 50 60 70 80 90 100
HEAVY DUTY PUMP
LIGHT DUTY PUMP
REQUIRED FOR PRESSURE
AVAILABLE FOR USE LIFE

Here is why Pacific's heavy duty process pumps are more economical—



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PANAREZ Hydrocarbon resins
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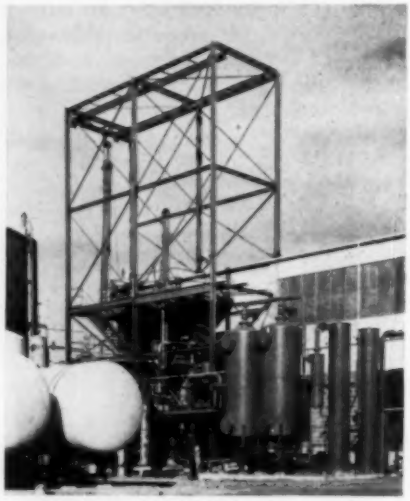
PANASOL Aromatic solvents

INDUSTRIAL NEWS

High purity anhydrous ammonia for industrial purposes will be produced in Pennsalt's new ammonia plant at Portland, Ore.

The plant, due to go on stream this spring, will use a high pressure modified Casale type process, and will utilize by-product hydrogen from Pennsalt's nearby caustic-chlorine plant.



New 26 million pound/year polyethylene resin plant has been brought on stream at Tuscola, Ill., by National Petro-Chemicals Corp., New York.

The plant, operating a modified ICI process from high-purity ethylene, produces all polyethylene precursors including the ethylene itself.

New $30 million **ammonia and nitrogen solutions plant** of Escambia Bay Chemical Corp., to be constructed this year, will be **only plant of its type** on the Gulf Coast east of New Orleans.

Escambia Bay, new petro-chemical company, will be owned by United Gas Corp., Electric Bond and Share Corp., and National Research Corp. M. A. Abernathy of Shreveport, La., will be president.

Intended to serve Florida, Georgia, south Mississippi, south Alabama, and parts of South Carolina, the plant will produce ammonium nitrate, anhydrous ammonia, nitric acid, nitrogen solutions, and other by-products for industrial and agricultural use.

New source of chlorine and caustic became available to southern industry on March 1 when Diamond Alkali's recently acquired Muscle Shoals plant went on stream.

First tank-car of chlorine has already been delivered.

Milling

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That's the way it is with stainless steel. And—important fact—varying amounts of chromium and other metals can be alloyed with steel to give stainless the specific all-the-way-through character needed to meet special problems.

Sun Ship has earned a reputation for mastering many special problems in its decades of service to the chemical, petrochemical, petroleum and other industries which face problems in fabrication and specialized machinery.

Now, with its new segregated Alloy Products Shop in operation, Sun Ship is using its experience and precise workmanship to adapt the superb qualities of stainless steel and other alloys to the equipment needs of the many industries it serves. In this shop are fabricated all grades of stainless, alloy, and aluminum.

Our Sales Engineering Department will be glad to discuss the value of this shop and its products in meeting your specific problems.

Sun Ship also makes all types of carbon steel pressure vessels.

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* *"Research means you do not know but are willing to find out"* —CHARLES KETTERING

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13A Impervious Graphite. Karbate brand combines features of corrosion resistance, thermal shock immunity, high conductivity, etc. National Carbon Co.

14A Corrosioneering News. For information on an announced corrosion guarantee see Corrosioneering News from Pfaudler Co.

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32A Vacuum Pump. Seal-less Chempumps fill the need for solution of leakage & vacuum problems. Virtually maintenance free. Chempump Corp.

33A Anhydrous Ammonia. Now on stream another ammonia synthesis plant producing 250 ton/day & built by Foster Wheeler Corp.

34A Crystallizers. If you have a crystallization problem experienced engineers are available for consultation. Struthers Wells Corp.

36A Filters. These units built in accordance with ASME code for pressures 75 to 1,500 lb./sq.in. are fabricated of corrosion resistant materials. Niagara Filters Div., American Machine and Metals, Inc.

39A Hot Spray Vinyl. Adhesion, thickness, density all said to be available in Tygon hot spray vinyl Saves 20% to 30% painting costs. U. S. Stoneware Co.

41A Heavy Duty Pumps. Entire Series H Durcopumps is accommodated by three bearing housings & suitable adaptors. Available in eleven standard Durco alloys. Duriron Co., Inc.

42L Oil Reclaimer. Purification of vacuum pump oil by continuous recirculation on basis of your requirements. Automatic operation. Hilliard Corp.

43A Air Preheater. Said to save one barrel in every five the Ljungstrom air preheater recovers much waste heat from exit gases. Air Preheater Corp.

44L Swivel Fittings. Manufactured in popular sizes & for practically every type of service have ease of turning & are good packing against leakage. Emsco Mfg. Co.

Chemical Engineering Progress

Numbers followed by letters indicate advertisements, the number corresponding to the page carrying the ad. This is for ease in making an inquiry as you read the advertisements. Letters indicate position—L, left; R, right; T, top; B, bottom; A indicates a full page; IFC, IBC, and OBC are cover advertisements.

Be sure to give name, address, position, etc.

Remember, the numbers on the upper portion of the card bring you data on only the bulletins, equipment, services, and chemicals reported in these information insert pages. The lower portion of the card is for the advertised products, and is keyed not only to advertising pages, but also to the memory-tickling list under the heading Products.

45A Anodes. GLC anodes used in electrolytic cell operations prove their usefulness & prime importance. Great Lakes Carbon Corp.

46-47A DeMisters. Improve the performance & increase throughput of your process vessel handling both liquid & vapor phase materials by use of Yorkmesh demisters. Otto H. York Co., Inc.

49A Insulation. Complete insulation engineering service assures you of dependable materials, application, engineering. Write to Johns-Manville.

51R Process Pumps. Whether your process pumps are horizontal or vertical you will be interested in the comparative picture of what these units can do. Pacific Pumps Inc.

52L Resins. If you compound or use rubber for products Panarez resins available in unlimited supply might be helpful. Pan American Chemicals Div., Pan American Refining Corp.

53A Stainless Steel. All grades of stainless steel & aluminum now available from a special alloy products shop. Also carbon steel pressure vessels. Sun Shipbuilding & Dry Dock Co.

54A Research. This division another facet of multi-service operation designs new or improved processes & products offered to industry to The Fluor Corp., Ltd.

59A Spray Dryer. Bakelite company produces first microballoon phenolic spheres in Bowen Spray Dryer. Bowen Engineering, Inc.

63A Pulverizers. Direct drive type Mikro-Pulverizers installed in a chemical plant process potassium perchlorate for end use in rocket fuel. Many new features. Metals Disintegrating Co., Inc.

(Continued on back of this insert)

Please do not use this card after August, 1955

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Advertisers' Products

IFC	3R	4A	5A	6L	7A	8A	9A	10A
11A	12A	13A	14A	15A	16L	17A	18L	19-20A
21A	22A	23A	24A	25R	26L	27A	28L	29A
30A	32A	33A	34A	36A	39A	41A	42L	43A
44L	45A	46-47A	49A	51R	52L	53A	54A	59A
63A	65A	67A	68L	69A	70L	71A	72L	73A
74L	75A	76L	78L	79A	80L	81R	82L	83R
84L	85R	86TL	86BL	87R	88L	89R	90L	91R
92L	93R	94TL	94BL	95R	97R	99R	100L	101TL
101BL	101TR	101BR	102L	102TR	102BR	103TR	103BR	104TL
104BL	105TR	105BL	105BR	106TL	106BL	107TL	107BL	107R
112L	112TR	112BR	113R	206A	IBC	OBC		

Chemical Engineering Progress Data Service

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Company .....

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City .....Zone.....State .....

☐ I want a subscription. Bill me $6.00 for a year.

May, 1955

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Advertisers' Products

IFC	3R	4A	5A	6L	7A	8A	9A	10A
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21A	22A	23A	24A	25R	26L	27A	28L	29A
30A	32A	33A	34A	36A	39A	41A	42L	43A
44L	45A	46-47A	49A	51R	52L	53A	54A	59A
63A	65A	67A	68L	69A	70L	71A	72L	73A
74L	75A	76L	78L	79A	80L	81R	82L	83R
84L	85R	86TL	86BL	87R	88L	89R	90L	91R
92L	93R	94TL	94BL	95R	97R	99R	100L	101TL
101BL	101TR	101BR	102L	102TR	102BR	103TR	103BR	104TL
104BL	105TR	105BL	105BR	106TL	106BL	107TL	107BL	107R
112L	112TR	112BR	113R	206A	IBC	OBC		

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☐ I want a subscription. Bill me $6.00 for a year.

May, 1955

PRODUCTS (*Continued*)

65A **Tubing.** A type available for every pressure tubing application. Meets all dimensional & mechanical requirements & available in range of materials. Babcock & Wilcox Co.

67A **Process Equipment.** High quality products for any purpose are designed, engineered, & fabricated by Acme Coppersmithing & Machine Co.

68L **Indicators.** Simply operated inexpensive installations which give continuous performance without constant attention. Barton Instrument Corp.

69A **Valves.** New, an improved-design 60,000 lb./sq.in. valve said to provide greater safety. Prevents unsafe use of lower pressure fittings. Autoclave Engineers, Inc.

70L **Junior Tube Cleaners.** If your need is to clean small tubes fast Rotojet tube cleaners are available for use in boilers, evaporators, other tubular apparatus. Elliott Co.

71A **Modern Plants.** Engineering services available for design & construction of complete process plant projects. Badger Mfg. Co.

72L **Mechanical Seals.** Chemiseal mechanical seals combine impervious Teflon with balanced bellows design. Sizes ⅞ to 2⅛ in. Other sizes on application. United States Gasket Co.

73A **Zipper Conveyor.** For use in handling ammonium chloride a zipper conveyor-elevator. Made of rubber it is immune to corrosion because it zips closed excluding corrosive dust. Stephens-Adamson Mfg. Co.

74L **Dryers & Heaters.** Indirect-fired these units dry without contamination from combustion gases, regardless of fuel. Fabricated with heat & corrosion-resistant metals. Hardinge Co., Inc.

75A **Plastic Equipment.** Over twenty years experience is record in fabricating equipment from tanks to fume stacks from laminated polyester glass. Haveg Corp.

76L **Catalyst.** Production of ammonia increased 40% using G-29 without increased use of fuel per unit of ammonia produced. Girdler Company.

78L **Liquid Level Control.** Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out. Magnetrol is so simple it precludes failure. Magnetrol, Inc.

79A **Pipe Insulation.** Called Unibestos this single-layer pipe insulation said to afford excellent protection. In 3 ft. lengths for pipe sizes 3½ through 24 in. Union Asbestos & Rubber Co.

80L **Spray Dryers.** Flexibility of operation, & automatic control, are features of this equipment. Offers high thermal efficiency. Proctor & Schwartz, Inc.

81R **Oxygen Analyzers.** For safety & product protection in the process industries savings in your operations are possible using these instruments. Arnold O. Beckman Inc.

82L **Proportioning Pumps.** Give trouble-free performance on troublesome fluids. One, two, three & four feed assemblies. Hills-McCanna Co.

83R **Filter.** Retractable tank heavy duty filter which gives 1,000 sq. ft. of filter service. Open in 60 sec. without disconnecting pipe. Sparkler Mfg. Co.

84L **Lab Dryer.** A portable lab dryer for purchase or rental, fully instrumented & ready to go to work at once. C. G. Sargent's Sons Corp.

85R **Heavy Duty Gear Pump.** Hydrex needs no costly speed reducer. Can be connected to 1,800 rev./min. Easily installed, less downtime, longer life. Sier-Bath Gear & Pump Co., Inc.

86TL **Catalyst Supports.** Even if yours is a unique problem there are more than two dozen types to select from in a variety of compositions. Carborundum Co.

86BL **Filter Presses.** Called Hydro-Klosers these closing devices installed on your filter presses eliminate time loss & hard labor. T. Shriver & Co., Inc.

87R **Jacketed Pumps.** These horizontal jacketed pumps are designed for pumping sulphur, waxes, etc. Heating medium can be steam, dowtherm, or other. Lawrence Pumps Inc.

88L **Chemical Feeders.** Where foaming is a problem use Manzel feeders. Models of large & small capacity for feeding at rates of a few drops to 60 gal./hr./feed. Frontier Industries, Inc.

89R **Expansion Joints.** Types for every application. Relieve stresses & strains, stop vibration, flange breakage. Made of Teflon, rubber, & Neoprene. Garlock Packing Co.

90L **Rotary Pump.** An external bearing pump without stuffing box, gaskets or valves. Capacities 5 gal./min. with 0 to 50 lb./sq.in. discharge. Vanton Pump & Equipment Co.

91R **String Discharge Filter.** This rotary vacuum string filter accomodates almost any filter cake. No scraping wear insures long life. Filtration Engineers, Inc.

92L **Wire Cloth.** Fabricated from all corrosion resistant metals this wire cloth is woven in wide range of meshes. Newark Wire Cloth Co.

93R **Filters.** For continuous filtration of molten sulphur. Special filtering problems. R. P. Adams Co., Inc.

94TL **Spray Booths.** Pigment & impurities are driven from the air stream by Centri-Merge. Booths designed to meet exacting operational requirements. Schmieg Industries, Inc.

94BL **Filtration.** Catalog on filtration & its application to your process. Classified for quick reference. D. R. Sperry & Co.

95R **Stainless Steel Valves.** 100% X-ray of all vital cast components guarantees high quality. This plus complete pre-testing program. Cooper Alloy Corp.

97R **Mixers.** Useful for mixing a wide variety of formulations homogeneously, readily cleaned, high capacity, low maintenance. Paul O. Abbe Inc.

99R **Pumps.** Universal pumps for lab, pilot plant & low volume chemical feed in production service. ECO Engineering Company.

100L **Polyethylene Ware.** Light weight containers useful for shipping or storage of corrosive chemicals, also distilled water. Ace Glass Inc.

101TL **Spray Nozzles.** Your exact needs can be met from a wide choice of spray nozzle types & capacities. Strainers also available. Spraying Systems Co.

101BL **Chemical Pumps.** Built of Ircamet a high-nickel-chromium-molybdenum alloy steel these pumps stand up under constant handling of corrosive & abrasive liquids. Ingersoll-Rand Co.

(Continued on page 60)

BAKELITE is a registered trade-mark of Union Carbide and Carbon Corporation

MICROBALLOON is a registered trade-mark of Sohio

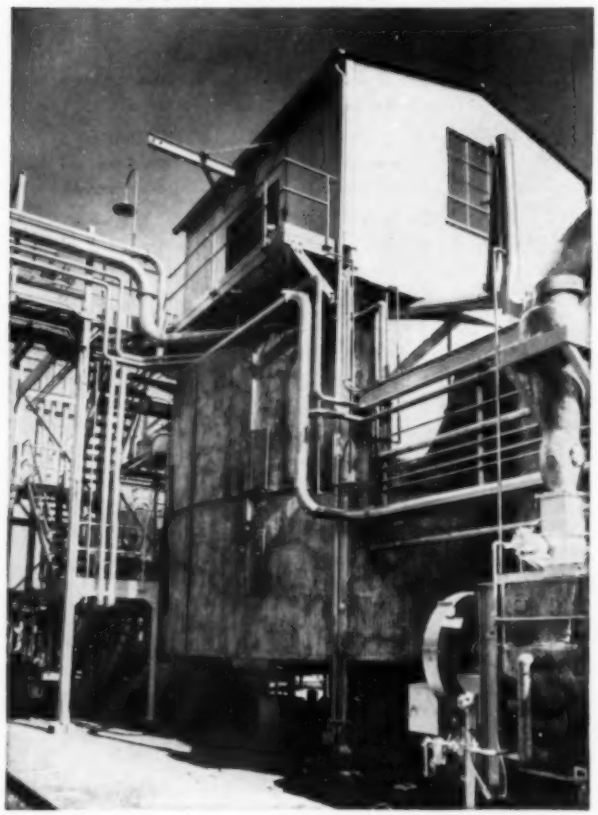
SPRAY DRYER PIONEER

Bakelite Company produces first Microballoon phenolic spheres in Bowen Spray Dryer

Bakelite's Nitrogen-Filled Microscopic Spheres Will Save Millions of Dollars Annually

Microballoon spheres floating on crude oil in laboratory storage tank.

The Bowen Spray Dryer which produces the gas-filled plastic spheres.



Microballoon spheres, developed by Standard Oil Company of Ohio, using a Bowen Laboratory Spray Dryer, were first commercially produced and marketed by Bakelite Company, a Division of Union Carbide and Carbon Corporation.

Evaporation loss of crude oil, averaging four out of every hundred barrels, and amounting to sixty million dollars annually, can now be reduced by 80-90 per cent with new Microballoon spheres.

A floating blanket of these tiny phenolic spheres filled with inert nitrogen gas float on top of crude oil and form a tight seal which reduces the escape of the more volatile fractions of the oil into the air. The resistance of Bakelite phenolic resin to oils and most other chemicals prevents the spheres from sinking to the bottom of the storage tank. Enough oil is saved from evaporation to pay for the Microballoon sphere installation in a year or less.

Bowen Engineering is proud to have had the opportunity to cooperate in this project.

Write for this Interesting Book

THE BOWEN LABORATORY SPRAY DRYER

We will be glad to send it — No obligation

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

BOWEN SPRAY DRYERS
Always Offer You More!

Recognized Leader in Spray Dryer Engineering Since 1926

PRODUCTS

(Continued from page 58)

101TR **Lab Ovens.** For use at temperatures 650° to 1,000° F., ovens have both Centigrade & Fahrenheit scales, & are stainless steel construction. Grieve-Hendry Co., Inc.

101BR **Pipe Bends Welded Assemblies.** Fabricated from ferrous or non-ferrous pipe or tube in range from ½ to 8 in. iron pipe size. Engineering data book available. Rempe Co.

102L **Antifoam.** Use of this silicone defoamer restores productive capacity previously wasted, reduces process time, eliminates boilovers. Dow Corning Corp.

102TR **Claw Propeller.** A stainless steel claw propeller said to speed production & improve mixing results. Designed & engineered by Craddock Equipment Co., Inc.

102BR **Dust Sampler.** Called Konisampler unit employs principle of thermal precipitation. Has automatic timer but will also operate continuously. Joseph B. Ficklen, III.

103TR **Punches & Dies.** Available for immediate delivery on standard sizes—4 to 5 weeks on specials. Arthur Colton Co.

103BR **Vaporizers.** Standard designs in both vertical & horizontal installations for ammonia, propane, chlorine. Richard M. Armstrong Co.

104TL **Skin Protection.** Called Kerodex substance said to give effective protection against skin irritants encountered in industry. Ayerst Laboratories.

104BL **Centrifugal Pumps.** Designed for abusive service units handle hot liquids, slurries, abrasive mixtures. Horizontal or vertical shafts. Nagle Pumps, Inc.

105BL **Arched Wafers.** A new process & a new service. Arched wafers of product said to have advantages over other shapes. Flakice Corp.

105TR **Plastic Tanks.** These tanks help you to transport liquids cheaper & better. Provide protection against corrosion resistance & electrical insulation. Carl N. Beetle Plastics Corp.

105BR **Surface Pyrometer.** Designed for both plant & laboratory surface & sub-surface temperature measurements. Five standard ranges. Pyrometer Instrument Co.

106TL **Combined Services.** If your problem is chemical engineering design, mechanical engineering development, or facilities for manufacture it is available from Artisan Metal Products, Inc.

106BL **Blenders.** An automated blending system of high accuracy, inclosed, continuous production. May be integrated with packaging & accounting. Bowser, Inc.

107TL **Reflux Heads.** Automatic distillation reflux heads electrically operated for high vacuum, pressure & temperature, plus corrosive & hazardous service. Distillation Engineering Co.

107BL **Ejectors.** Line of steam jet ejectors, condensers, vacuum equipment. Have corrosion resistant parts interchangeable with standard parts. Jet-Vac Corp.

107R **Valves.** Dust-Tite valves are self-cleaning, free flowing, & spherical in shape. Seat & disc designed for severe use. General Machine Co. of New Jersey.

112L **Vitreosil.** Material has chemical & catalytic inertness, plus good electric properties. Useful for exacting laboratory needs. Thermal American Fused Quartz Co., Inc.

112TR **Process Pump.** For pumping liquids, gases, or slurries without corrosion or contamination. Steel fingers force material through tubing. Sigmamotor, Inc.

112BR **Research.** Industry, science, government—all have used our services for many years. If you have a problem, write us. Foster D. Snell, Inc.

113R **Evactors.** The C-R chill-vactor is but one type of steam-jet evactor manufactured. Submit your problems to our technical staff. Croll-Reynolds Co., Inc.

206A **Centrifugal Pumps.** If your need is faster centrifuging at lower cost Tolhurst makes 7 sizes in capacities of 1 to 17 cu. ft./load. American Machine and Metals, Inc.

IBC **Controlled Volume Pumps.** A new bulletin available which provides economical solutions to every industrial water treatment problem. Milton Roy Co.

OBC **Mixing.** Full description of Lightnin mixers plus many helpful facts on mixing contained in available literature or from representatives of Mixing Equipment Co., Inc.

BULLETINS

1 **Control Pilots.** Liquid level, pressure & temperature functions of instrument fully described in bulletin from Leslie Co. Pilot design illustrated with cutaway drawings. Lists principal uses, specifications, other data.

2 **Storage Tanks.** Standard storage tanks fabricated from open hearth, high quality steel by Buffalo Tank Corp. are subject of illustrated folder. All Underwriter approved. Capacity tables & dimensions included.

3 **Piping.** From Vitaulic Company of America catalog of piping & fittings for all types of pipe formed from various materials. Tables of dimensions, cutaway views, operating features, other data listed.

4 **Air Reduction.** Reference manual from Air Reduction Co., Inc. describes in general, various products & services of all its divisions. Complete & written in simple language should prove handy source of information for those requiring it.

5 **Recording Charts.** Technical Charts, Inc., have made available a catalog outlining production of recording charts for standard & special instruments. Includes both dial & roll charts. Outlines production method for over 8,000 different standard charts. Information available on special charts.

6 **Screens.** Vibrating screens for all medium & heavy duty screening, covered in illustrated catalog from Link-Belt Co. Vibration amplitude adjustable to suit material requirements. For use in scalping, sizing, dewatering & rinsing. Handle variety of materials.

7 **Mixers.** An intensive mixer with claw mixing propellers called Mixall described & illustrated in leaflet from Craddock Equipment Co., Inc. Models from 1/6 to 3 H.P.; blade sizes 3 to 12 in. diam.

8 **Titanium Tubing & Pipe.** Carpenter Steel Co. binder insert describes titanium tubing & pipe, lists physical properties, applications, information on machining & corrosion resistance, availability, other data.

9 **Pumps.** Chempump a pump without seal or stuffing box is described & illustrated in catalog from Chempump Corp. Gives information on sizes, heads, capacities, construction, design. Sizes ⅛ to 7½ H.P. Units give leakproof, low maintenance pumping at heads to 195 ft., capacities to 250 gal./min.

10 **Rotary Pump.** Designed for special use in marine, petroleum, process industries, rotary pumps from Geo. D. Roper Corp. Illustrated catalog lists all pertinent details. Shows diagrams of various types.

BULLETINS

Gives 3-way air pollution control. Other products shown

11 **Packaged Pilot Plant.** Now available from Patterson-Kelley Co., Inc. a product data sheet on a 5 gal. distillation pilot plant. Consists of reactor, agitator, condenser & decanter. For use in studying many chemical process operations. Specifications included on component parts, electrical controls, cooling & heating systems.

12 **Photometer.** Universal 1000 series of photometers from Phoenix Precision Instrument Co. operate on any 115 v. 60 cycle line. Feature rugged construction, are portable, internally regulated, etc. Also available are special light scattering types as well as custom built units. Bulletin shows cutaway views gives all pertinent information.

14 **Separation Units.** Two leaflets from Hart-Carter Co. cover their precision grader for accurate sizing of grain & other granular materials by thickness or width, also a unit for length separation & sizing of grain, seed, & other granular materials. Both are illustrated & detail uses, construction, sizes.

15 **Blinds, Spacers, Figure 8s.** Encoa blinds, spacers, figure 8s for installation between two companion flanges in any pipe line provide permanent & positive shutoff of fluid flow. For pipe line sizes 1 through 24 in., with full range of pressure & temperature ratings. Catalog lists dimensions & weights for specific services. Engineering Corporation of America

16 **Spray Dryer.** A semi-works spray dryer from Bowen Engineering, Inc. of stainless steel construction, available where small compact spray dryer is desired. Specially designed drying chamber, unit is portable through usual openings. Typical installations illustrated in folder.

17 **Teflon Rods.** Just off the press a folder from Garlock Packing Co. which describes physical properties of two grades of Teflon available in rod form to fabricators of finished Teflon parts. One made from virgin Teflon powder, the other from reprocessed Teflon. Typical uses listed, also complete price & size information.

18 **Thermal Precipitator.** Now available for aerosol sampling, a compact thermal precipitator for air pollution surveys, monitoring foreign material in gas, control of dust & fume exposures, other uses. Leaflet lists special features, specifications, weight, price, etc. of Konisampler from Joseph B. Ficklen, 3rd.

19 **Hydraulic Flow Regulator.** Said to be exceptionally accurate a 3,000 lb./sq. in. aircraft hydraulic flow control valve giving free return flow. Available in tube sizes from ¼ to ¾ in., with 10,050 and/or 10,056 ports. Flow volume regulation as required. Also measures leakage flow. Illustrated catalog sheet. Sterer Engineering and Mfg. Co.

20 **Distillation Plants.** Standard or unusual distillation plants from Process Plants Engineering Co. discussed in folder. Specialists in design & supply of complete units for fractional or straight distillation, evaporation, absorption, or extraction. If required laboratory & pilot plant of company will run tests on materials at nominal fee.

21 **Prefabricated Lab Walls.** Space flexibility achieved by use of Mobil-lab-walls designed specifically for laboratories of 6 in. thick movable steel partition. Bulletin contains illustrations of installations, typical lab plans, specifications. Virginia Metal Products, Inc.

22 **Combustion Chambers & Karbate Nozzles.** Issued by National Carbon Co. new catalog section on National graphite combustion chambers & Karbate burner nozzles for producing hydrogen chloride. Contains dimensioned drawings plus complete description with emphasis on burning ability, corrosion resistance, ability to withstand thermal shock. Chamber sizes 12 to 14 in. diam.; capacities 3 to 13 ton hydrogen chloride per 24 hr. period.

23 **Graphite Electrodes.** Announced by United Carbon Products Co. modern catalog of graphite electrodes for the spectroscopic profession. Information & specifications on performed custom electrodes, the Platrode series, ultra pure graphite rods & powders.

24 **Process Equipment.** Complete line of Buflovak Equipment Div. of Blaw-Knox Co. listed & illustrated in new catalog. Includes for first time Roto-Vak concentrator, Roto-Shelf cooler, individual side conveyor drives for double drum dryers, continuous glue dryers, & others.

25 **Clad Steel Manual.** Combining the experience of many fabricators of clad steel equipment with research & development work by them, revised manual from Lukens Steel Co. Covers manufacture of clad steels plus physical & chemical properties of each. Detailed sections on flame cutting, forming, welding & finishing. Also plate sizes, weights, tolerances, other specifications.

26 **Gate Valves.** Stainless steel gate valves are the subject of a catalog from Cooper Alloy Foundry Co. Shows schematic drawings of various types, includes design factors, information on materials of construction, standards, & quality control. Also a table of major stainless alloys with designations & applications.

27 **Plastic Pipe, Fittings & Valves.** Technical data on Dur-Ace general purpose corrosion resistant plastic pipe with high impact strength & toughness given in bulletin from American Hard Rubber Co. General properties of multipolymer rigid plastic pipe, pressures, installation & fabrication data given.

28 **O-Rings.** Garlock Packing Co. line of O-rings covered in complete catalog. Gives design information, recommended pressures, available materials for both dynamic & static applications. Also complete list of standard sizes & those in stock, schematic drawings, other data.

29 **Thermocouples & Pyrometer Accessories.** Bulletin from Bristol Co. on thermocouples & pyrometer accessories serves both as a buyer's guide & user's manual. Contains much engineering data on selection & installation of proper types. Many illustrations & line drawings included. Also calibration tables based on new NBS paper 2415 & circular 508.

30 **Engineering Services & Equipment.** Design, research, construction & operation in industrial, chemical, metallurgical, & sanitary engineering fields, with thermal processing are services available from Nicholas Engineering & Research Corp. Illustrated folder shows schematic drawings of various units with detailed information on each.

31 **Abrasive Fluid Valves.** Mudwonder alloy steel valves designed for mudline service in the oil industry are also suitable for other abrasive fluid applications. Catalog section from Edward Valves, Inc. gives sizes & materials, & emphasizes design simplicity. Sizes, 2-, 3-, & 4-in. valves, rated 2,000 & 3,000 lb./sq. in. in W.P. with either flanged or screwed ends.

32 **Maintenance.** Anderson-Nichols & Co. offer a new 28-page brochure which discusses size & complexity of today's maintenance problems. Also a program for plan & control of plant maintenance. Covers organization, personnel, facilities, methods, controls, reports & policy.

33 **Screening Equipment.** Efficient removal of solids from water, sewage, & industrial waste is considered in book from Link-Belt Co. Complete dimension & specification data for 4 types of coarse screens & 3 types of fine screens. Pictures of typical installations, schematic drawings, tables, & details given.

(Continued on next page)

BULLETINS

(Continued from page 61)

34 **Heat Exchangers.** National Radiator Co. shell & tube heat exchangers for the chemical & petroleum industries described in folder. Designed & built to meet ASME, API or other specifications, & especially useful in handling of hazardous inflammable liquids. Many engineering drawings included.

35 **Manhole Fittings.** Lukens Steel Co. manhole fittings—one type can be used at working pressure to 30% greater than usual—of an exclusive elliptical design now available from stock. ASME Boiler Committee approved for pressures from 150 lb./sq. in. in single yoke type weighing 24 lb. up to the 1,000 lb./sq. in. cover.

36 **Precipitator Accessory.** The MI Rapper, a device for automatic & continuous cleaning of collection electrodes on the Cottrell electrostatic precipitator is described & illustrated in folder from Research-Cottrell, Inc. Schematic diagrams, operating information, components, remote control unit all covered.

37 **Industrial Gas Equipment.** Entitled "Kemp Case Histories," bulletin from C. M. Kemp Mfg. Co. features installations of industrial gas equipment. Photographs illustrate how to save time & money & increase production through use of immersion heaters, dynamic dryers, & inert gas generators.

EQUIPMENT

50 **Industrial Glasses.** For eye-protection programs requiring light-impact protection, a new FeatherSpec announced by Willson Products, Inc. Ample protection for light grinding, woodworking, spot welding, inspection & other jobs not requiring heavy-duty goggles. Illustrated leaflet shows several types with variety of lenses available.

51 **Mechanical Seal.** Wedge-lock external mechanical seals which may be installed in 30 min. available from Chemical and Power Products, Inc. Designed for complete interchangeability with stuffing-box packing in pumps, agitators, autoclaves, & other rotating process equipment. Variety of other seals available.

52 **Temperature Controls.** Bulletin from Burling Instrument Co. illustrates three new models. Each is a dual temperature control which incorporates two independent electric switches for operation to 1,800° F. Models differ only in type of enclosure. Standard switches 15 amp., 125 to 250 v.a.c., & are actuated by tube expansion through a lever.

53 **Electric Proportioning Control.** Announced by Leeds & Northrup Co. in illustrated bulletin, two new instrument lines, Speedomax type H controllers & series 60 proportional-control units. Type H presently available in single-point only & only for temperatures with thermocouple. For on-off control Speedomax available as a strip-chart, non-recording controller, also as non-controlling recorder.

54 **Temperature Control.** Burling Instrument Co. leaflet features their model LD-1S indicating temperature control. For use in industrial ovens, liquid baths, dryers, ducts, & laboratories. Operation, temperature ranges, all other details listed.

55 **Process Equipment.** From Edw. Renneburg & Sons Co. bulletin on their DehydrO-Mat. Unit said to be of improved design. Principal difference is single shell of wide variation in diameter rather than straight cylinder. Individual parts illustrated—schematic diagram of unit. Gives 3-way air pollution control. Other products shown in diagrams & illustrations accompanied by descriptive material.

56 **Control Valve.** Described in bulletin from Red Jacket Co. a new type of control valve fabricated from rubber. For handling solids in suspension. May be manually or pneumatically operated. Sizes 1 to 24 in. Unit is packless, springless, has no moving parts, only one wearing part, permits unobstructed flow.

57 **Pressure Transmitter.** Announced by Barton Instrument Corp. a differential pressure transmitter said to accurately transmit flow, liquid level, and/or differential pressure at high speed of response with low consumption of air. Adverse conditions said not to affect operation. Easily operated by unskilled personnel.

58 **Agitation of Pressure Vessels.** Successful application of canned motors to agitation of pressure vessels accomplished by units from Pressure Products Industries, Inc. Available in range of voltages, speeds, & powers. Permits research size vessels to be scaled to pilot plant & plant size equipment. Capacities 250 ml. to 25 gal., & pressures to 100,000 lb./sq. in.

59 **Proportioning Pumps.** Designed for micro flow rates the Pulsafeeder pump from Lapp Insulator Co., Inc. No stuffing box or running seal to contact liquid being pumped. Construction permits use of standard 1/20 H.P. electric motor without gear reduction or other special features. Dial indicator calibrated in 1,000 increments. Folder.

60 **Chemical Feeders.** Models E & H low capacity chemical feeders announced in bulletin from Proportioneers, Inc. Leaflet. Called Chlor-O-Mite & offered as a packaged unit they may be electrically or hydraulically operated. Feeders & typical arrangements for constant rate, intermittent, flow-proportional & hydraulic pulse feeding shown.

61 **Cen...ugal Pump.** Availability of three additional sizes of the Oliver type L centrifugal pump announced. Range includes 1 to 1½ in. models in addition to the 2 in. original unit. Pump is highly corrosion resistant & said to contain new design elements. Major advantage is high cut-water or tongue of volute which makes unit self venting & cuts formation of air pockets. Dorr-Oliver, Inc.

62 **Direct Flow Pumps.** Availability of a line of 6 in. stroke Nonuplex direct flow pumps for heavy duty pumping applications announced by Aldrich Pump Co. Rated at 900 b.h.p., they operate at 300 rev./min., with pumping capacities to 1,520 gal./min. or 52,200 bbl./day. Six different fluid ends & 20 plunger diameters. Plunger size range 2 to 5¼ in. in increments either ⅛ or ¼ in.

63 **Totally-Enclosed Motor.** Now in production by U. S. Electrical Motors, Inc. an improved motor for units requiring enclosure. Conforms to dimensional standards of NEMA. No general disassembly required to gain access to bearings. Externally exposed surfaces made of cast iron. Numerous other improvements.

64 **Rotary Shaft Seal.** An easily replaceable rotary mechanical shaft seal designed for service in fluid mixing applications, from Mixing Equipment Co. Positive, leakproof sealing of tank liquids, vapors or gases, provided by new seal. Seal requires no adjustment. Gives long trouble-free service under normal conditions.

65 **Plastic Proportioning Pumps.** To increase ability to handle highly corrosive fluids Hills-McCanna Co. have designed a U type pump with two types of plastic

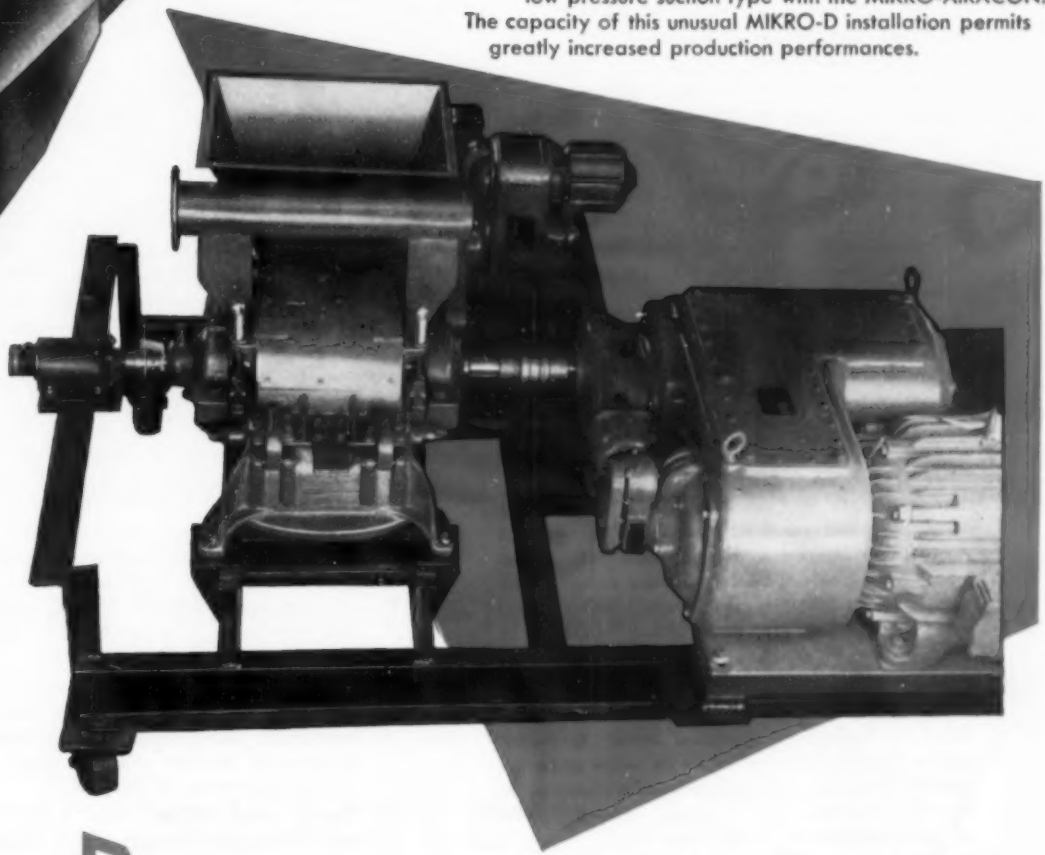
(Continued on page 64)

MIKROS help process materials for rocket fuel

Two big MIKRO-PULVERIZERS, of the direct drive type have been installed in a large chemical plant for use in the processing of potassium perchlorate used in rocket fuel.

The significant feature of this unusual installation is the inclusion of special devices such as tachometers, for remote control in the handling of a material which is hygroscopic and highly explosive. The two units, with a capacity of 3,000 pounds per hour, are vented by MIKRO-COLLECTORS of four filter cylinder capacity.

The installation also includes air-conveying of the low pressure suction type with the MIKRO-AIRACON. The capacity of this unusual MIKRO-D installation permits greatly increased production performances.



SEND FOR descriptive illustrated bulletin

Mikro-D PULVERIZER

PULVERIZING MACHINERY DIVISION
METALS DISINTEGRATING COMPANY, INC.
97 CHATHAM ROAD SUMMIT, NEW JERSEY 3017

PULVERIZING • AIR CONVEYING • DUST COLLECTING EQUIPMENT

EQUIPMENT

(Continued from page 62)

liquid ends. Pump body & check valve assemblies made from unplasticized PVC or Kel-F. Capacities to 19 gal./hr. per feed & are available in 2, 3, or 4 feed units. Maximum temperature of PVC pumps 150° F.; Kel-F pumps to 250° F.

66 **Cooling Tower.** A new prototype in cooling tower design from Santa Fe Tank and Tower Co. represents a rearrangement of standard tower parts. Called Wind-Trol it offers improved operating efficiency by controlling recirculation. High resistance to wind effects. Mounted on open substructure the tower & redwood basin are supported by cast-in-place concrete piles. Distribution area readily accessible for cleaning; flushing possible at ground level.

67 **Pressure Pilot.** Kieley & Mueller Inc. announce development of pressure pilots featuring self-contained controlled pressure gauges in compact overall units. Unitized construction & simple design overcome field calibration & maintenance problems. Full range of control operations in single unit. Proportional band & differential gap adjustable from 1 to 100% by turn of calibrated dial.

68 **Wedge Valve.** A valve which incorporates the sealing action of a line blind with simple operation of a gate valve developed by Hamer Valves, Inc. Called Visible Wedge, valve permits full view visibility of wedge at all times. Line movement unnecessary to open or close valve. Hand wheel permits opening or closing of valve in less than a minute.

69 **Control Initiating Instrument.** For installation on switchboard or panel instruments, an automatic, all-electrical device for initiating action when a predetermined value is reached. Available in one-set or two-set point initiation. Load relay supplied rate at 120 to 240 v., 10 to 5 amps., single pole double throw. General Electric Co.

70 **Laboratory Recorder.** From Fisher Scientific Co. a new laboratory recorder that converts manual laboratory instruments into automatic recording instruments. Records changes in potential, current, resistance, temperature, pH, pressure, vacuum, etc. Illustrated folder gives all details, also tables, other data.

71 **Teflon Seal.** Use of a new Teflon-ceramic seal on its corrosion resistant type No. 20 stainless alloy centrifugal pump announced by Eco Engineering Co. Gland is dimensionally identical & interchangeable with stellite-graphitized carbon seal used on standard pump. Recommended for applications where temperatures do not exceed 160° F. in continuous service. Capacity 25 gal./min. at 3,450 rev./min. with heads to 55 ft.

72 **Coatings.** Three new modifications of Phenoline 300 announced by Carboline Co. Detailed information contained in bulletin on Phenoline series. Emphasizes heavier thickness with fewer coats for longer protection. Explains testing programs, tells areas where coatings are recommended. Table shows primers required, number of coats, temperatures of use, other data.

73 **Flowmeter Calibration System.** Based on time & weight measurements a new flowmeter calibration system from Baldwin-Lima-Hamilton Corp. Instrument is a specially designed indicator-controller in which electrical indications of weight from load cell start & stop a timer automatically. Weight dial readable within one pound & timer dial gives time of flow to one-thousandth of a second.

74 **Flame Photometer.** New model 146 flame photometer styled for maximum ease of operation & performance, developed by Perkin-Elmer Corp. Incorporates several features which permit simple & precise read-out data. Uses a duo-prism monochromator, & highly stable & sensitive electronic amplifier. Accuracy ± 1%. Sample size of 5 to 5 cc. sufficient for analysis.

75 **Condenser.** A 200 ton refrigeration capacity ammonia condenser added to line of Niagara Blower Co. Basic operating principle is that of evaporating sprayed water from surface of condensing coils through which refrigerant gas passes, extracting heat at rate of 1,000 Btus./lb. water evaporated. Equipped with Duo-Pass precooling coil for removal of superheat from refrigerant gas. Unit measures 8½ x 14 x 16 ft. in height.

CHEMICALS

86 **Wall Chart.** A 35 x 44 in. wall chart which presents in sequential form chemical methods for the synthesis of ONCB compounds in three classifications: ring substitutions, chloro reactions, & nitro reactions. Shows more than 120 organic syntheses based on ortho-nitrochlorobenzene. Monsanto Chemical Co.

87 **Revised Chemical Index.** Reilly Tar & Chemical Corp. has just issued the second edition of the Reilly chemical index. Essential information on over 100 organic compounds, plus 13 new chemicals new since the first edition.

88 **Water Softeners.** A 20-page bulletin from Permutit Co. discusses in detail troubles caused by utilization of hard water. Includes specifications, operating characteristics, & typical installation photographs. Of interest to engineers dealing with water problems.

89 **Silicone Treatment.** Newly developed by Dow Corning Corp. a water-dilutable silicone treatment easily applied to give maximum scratch resistance to glass, porcelain, & china. Easily applied by dipping, flooding or spraying with conventional equipment. Concentrations as low as 0.01 to 0.1% instantly effective. Supplied from a 20% solution in tertiary butanol F-4141 is stable & has long shelf life.

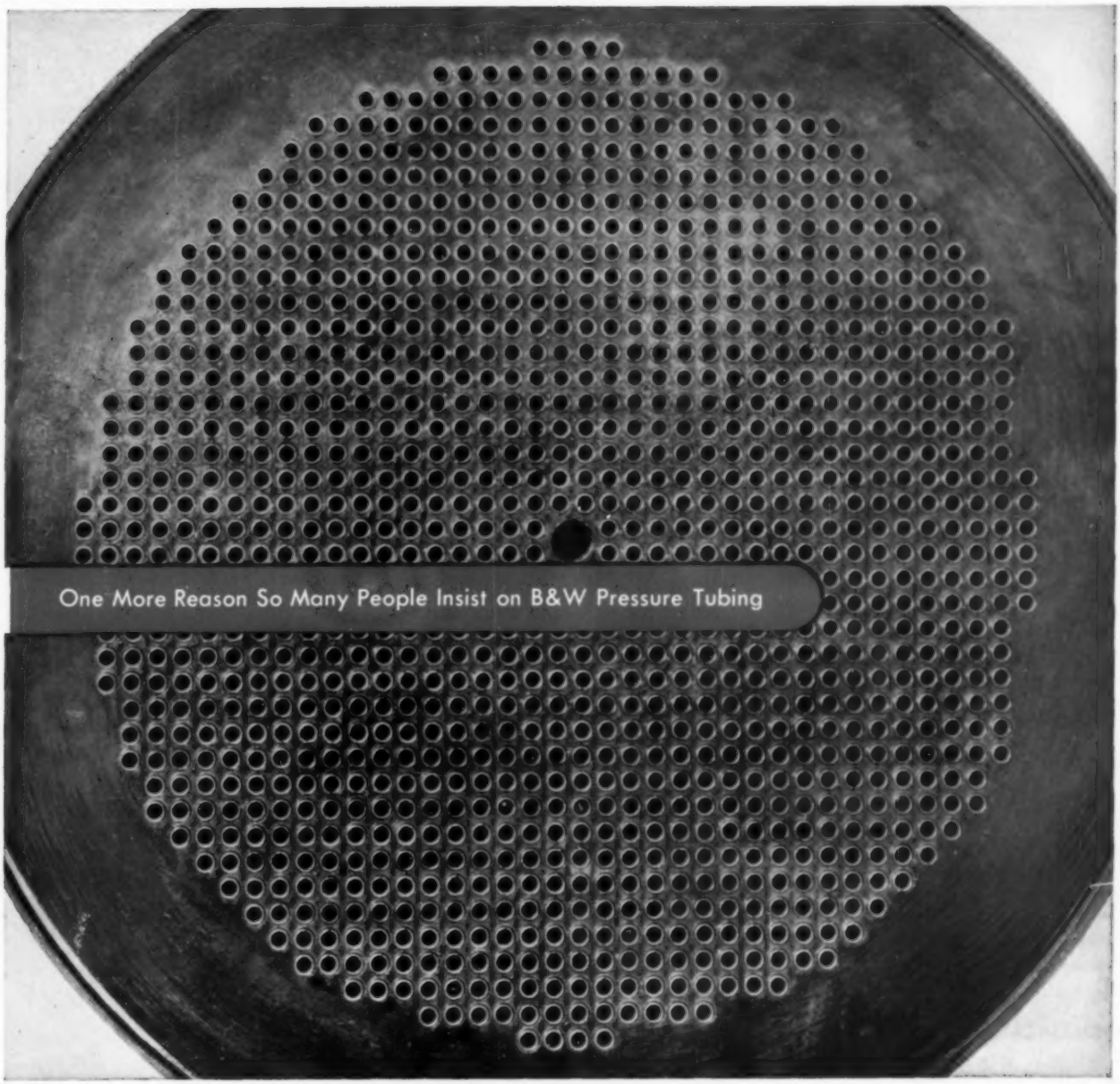
90 **Catalysts.** Revised product data sheets on powdered & pelleted vanadia oxidation catalysts & on indicating silica gel for protective packaging. Davison Chemical Co.

91 **Amorphous Silica.** From Philadelphia Quartz Co. announcement of a new amorphous silica. Particle size about 15 millimicrons. Material is white, free-flowing powder of very light weight with a surface area of 135 to 215 sq.m./gr. Available in either mildly alkaline or acid condition. It is hydrophilic, heat stable, completely insoluble & has high oil absorbency.

92 **Solvents.** Carbide and Carbon Chemicals Co. announce their book titled, "Cellosolve and Carbitol Solvents." Describes in detail nine commercial glycol-ethers sold by company. Features a section devoted to specifications of glycol-ethers & tests used.

93 **Platinum Metals Catalysts.** Baker & Co., Inc. offer their leaflet on selective hydrogenation by the platinum metals catalysts. Covers group & step selectivity as well as other phases.

94 **Hot Spray Vinyl.** Specifically engineered for economical & effective corrosion control a hot spray vinyl from Prufcoat Laboratories, Inc. Provides 4 mils in single spray pass. One prime & one hot coat give 5 to 6 mil total thickness. Vinyl thicknesses in 10 to 15 mil range without runs or sags possible.



B&W TUBING UNIFORMITY—MULTIPLIED 1194 TIMES

If you had this many tubes to roll in, there would be no delay if you used B&W tubes.

For heat exchangers, for condensers, in fact for every pressure tubing application, you can rely on B&W tubing for uniform wall thickness, uniform ductility, tight joints, and low installation cost.

Always specify B&W pressure tubing. It meets all dimensional and mechanical requirements, and is available, in all commercial sizes, in a wide range of carbon, alloy and stainless grades. *Write for Technical Bulletin CEP 329.*

B&W
TUBULAR PRODUCTS DIVISION

THE BABCOCK & WILCOX COMPANY
TUBULAR PRODUCTS DIVISION
Beaver Falls, Pa. and Milwaukee, Wis.: Seamless Tubing, Welded Stainless Steel tubing
Alliance, Ohio: Welded Carbon Steel Tubing
Milwaukee, Wis.: Seamless Welding Fittings

TA-5019(P)

NIONEL REFERENCE SHEET

(Part 1)

W. Z. Friend

International Nickel Company, Inc., New York

Nionel: A new nickel-base corrosion resisting alloy, latest addition to growing group of high-nickel Inco alloys has been developed to handle certain corrosive conditions of unusual severity. It answers a need not filled by any of the other Inco alloys in that it has the specific ability to withstand certain hot acids and oxidizing chemicals; it also has high resistance to other conditions. Nionel is available in all wrought mill forms.

APPROXIMATE COMPOSITION	%
Nickel	40.
Chromium	21.
Iron	31.
Molybdenum	3.0
Copper	1.75
Manganese	.60
Silicon	.40
Carbon	.05

Fabrication

Nionel can be welded by all of the standard welding methods using electrodes or filler wires specified for the purpose.

Available Mill Forms

Hot rolled sheet, plate and rod; cold rolled sheet and strip; seamless pipe and tubing; extruded seamless tubing; and cold drawn rod.

CHEMICAL PROPERTIES—GENERAL

Its relatively high nickel content, plus molybdenum and copper, makes the alloy considerably more resistant to reducing conditions such as hot sulfuric, sulfurous and phosphoric acid solutions than any of the common stainless steels. The chromium content is sufficient so that when fortified with nickel, the alloy is resistant to a wide variety of oxidizing chemicals such as nitric acid solutions, nitrates, and cupric, ferric, and mercuric salts, except chlorides. With this combination of properties, Nionel is expected to find many useful applications.

Nionel is not resistant to hydrochloric acid solutions or to wet chlorine or other halogens.

With regard to high-temperature applications Nionel is more scale resistant than the stainless steels but not usually as suitable as Inconel or Incoloy in applications where this property must be featured.

The behavior of Nionel in specific chemical environments will be summarized in the June issue.

MECHANICAL PROPERTIES†

Cold Drawn Tubing—Annealed

Size	Yield Strength lb./sq.in.	Tensile Strength lb./sq.in.	Elongation %	Hardness*	
5/8 in. O.D. × .048	43,000	94,000	43.0	64–6	30–T**
1 in. i.p.s.	54,000	99,000	47.0	88	
1 in. i.p.s.	53,000	100,000	36.0	94–5	

Cold Drawn Wire Rod—As Drawn

3/32 in diam.	158,000
1/8 in. diam.	155,500
5/32 in. diam.	153,500

Cold Rolled Sheets—Annealed

Size	Yield Strength lb./sq.in.	Tensile Strength lb./sq.in.	Elongation %	Hardness*
.062 in. × 36 in. × 96 in.	41,500	95,500	44.0	80–1
.109 in. × 36 in. × 96 in.	37,000	94,000	49.0	77

Cold Rolled Strip—Annealed

.125 in. × 1¼ in.	43,500	101,500	46.0	83

Hot Rolled Sheets—Annealed

.187 in × 26 in. × 50 in.	39,000	91,500	50.0	77–9

* Rockwell B

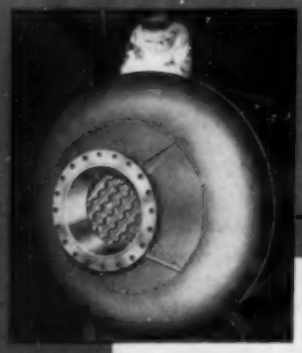
** Rockwell Superficial hardness

† These properties of Nionel should not be used for specification purposes; they indicate average properties obtained on several forms.

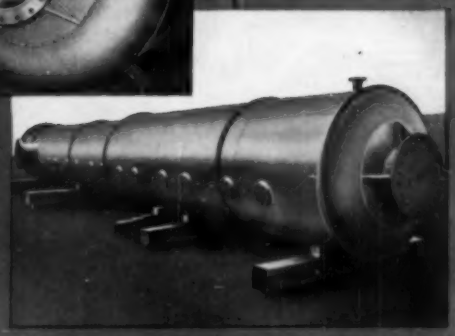
No. 45

VERSATILITY

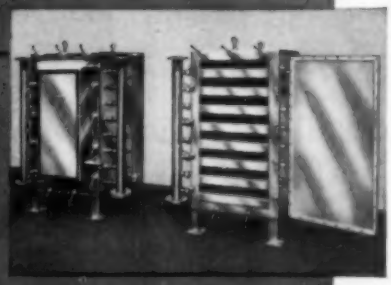
* DESIGN
* ENGINEERING
* FABRICATION



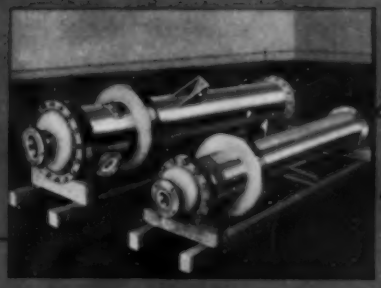
STEEL
Distilling Column



STAINLESS STEEL
Tray Dryers, ACME Design



COPPER
Scotch Whiskey Stills, 13' 7" and 12' 6" Diameters



ALUMINUM
Heat Exchangers

Leading Process Industries have come to depend on Acme for more efficient equipment for virtually any purpose. Acme versatility has paid dividends to many processors in time and effort saved, in greater economy of operation and more productive yields of high quality products.

The illustrations shown here are but a few from thousands of diverse units in current, successful use all over the world.

When planning a replacement or expansion program, consult Acme first!

ACME
Processing Equipment
ACME COPPERSMITHING & MACHINE CO., ORELAND, PA.
DESIGN AND FABRICATION IN ALL FERROUS AND NON-FERROUS METALS.

BOSTON

one-day meeting

There are more top executive jobs than fully qualified men to fill them. Coming to this conclusion, the one-day panel meeting of the Boston Section on the subject of "So You Want To Be An Executive," went on to analyze why this is and what an aspiring executive can do to become "fully qualified." The meeting, held in John Hancock Hall, drew 200 interested members and guests to hear the well-qualified panel, moderated by R. W. Merry, professor of Business Administration at Harvard, debate the pros and cons of being an executive.

An executive job is a tough one and, although very rewarding, the panel felt that many aspirants for the high-paying niche fall down in not being willing to give the required time and effort necessary to be an executive.

There are many sacrifices of time, personal life, outside interests, and leisure, demanded of the man who would be an executive. R. S. Morse, president of National Research Corporation, pointed out that a young man must decide early whether the rewards and compensations of executive position are worth the sacrifices required. In general, Morse observed, there are not enough men willing to make the sacrifices, hence more jobs than applicants.

Self Improvement—A Key

The man who is dissatisfied with his current state of knowledge, and is always striving to improve it, makes the best executive, said Maj. Gen. W. M. Creasy, chief chemical officer, Department of the Army. Creasy admitted that executives employed in civilian capacities by the Army are paid less than men in comparable civilian jobs, but he showed that for many men there are compensations in Army work which off-set this financial loss.

In outlining the desirable attributes of a research manager, E. D. Reeves, exec. v.p., Esso Research, actually pinpointed the attributes of any good executive: know the company's problems, be willing to take calculated risks, be ready to provide leadership, give the necessary morale to his subordinates. Perhaps most important, he must be a good enough salesman to "sell" what he believes is right for his firm.

Train From Within

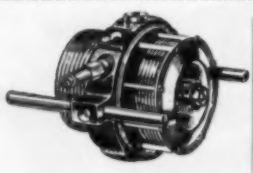
The importance of taking potential executives directly from college and "bringing them up" within the company, was emphasized by C. W. Humphreys, vice president, manufacturing, Shell Chemical. This is Shell's method and the company feels it is the method which produces the best executives with the highest morale.

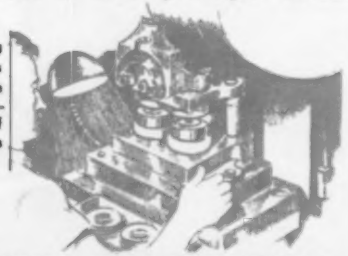
The growing complexity of the executive's job, and the concomitant need for better-rounded men, was pointed out by T. M. Hennessey, vice president, New England Tel. and Tel. It is this, as much as anything else, that has created the present situation of more jobs than properly trained men.

(*Continued on page 70*)

BARTON INDICATORS | *are a necessity in process industry when:* High accuracy . . . rugged construction . . . simple operation . . . inexpensive installation and low maintenance are desired.

For further information please request Bulletin 11c-4 or contact Barton sales representatives in most principal cities.


Model 199 Bellows Assembly "The Heart of all Barton Units"


Forming Operations of Barton Rupture-Proof Bellows

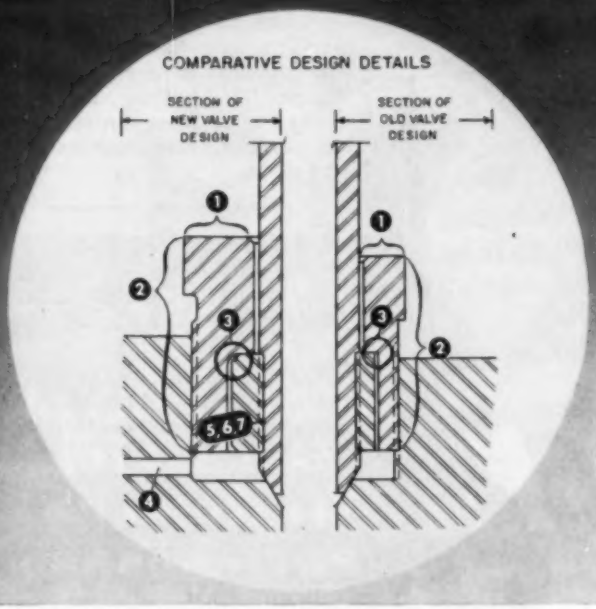
BARTON INSTRUMENT CORPORATION
INDUSTRIAL INSTRUMENTS
1429 SOUTH EASTERN AVENUE · LOS ANGELES 22, CALIFORNIA

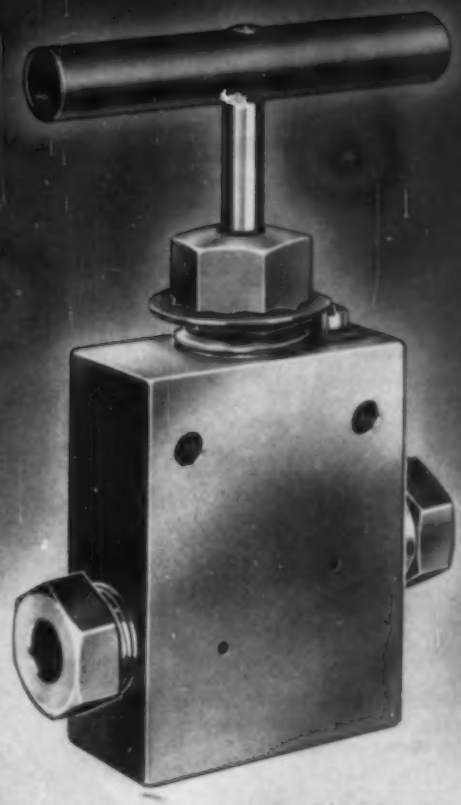
NOW . . . A New Improved-Design 60,000 p.s.i. Valve by Autoclave

Provides Greater Safety

Prevents Unsafe Use of

Lower Pressure Fittings





In their continuous effort to improve the operation of high pressure equipment, engineers and craftsmen offer you this new improved 60,000 p.s.i. valve. You will recognize that these design improvements provide greater operational safety and prevent interchangeability with lower pressure fittings:

1. The outside diameter of both the collar and gland is increased for added strength and safety.
2. The increased length of the gland permits longer thread engagement.
3. Internal corners are machined with a radius . . . corners on the collar are chamfered to minimize hazard at points of stress concentration.
4. Weep holes are drilled at the base of the female thread of the valves and fittings.
5. Threads with rounded root are used throughout to prevent interchangeability with lower pressure fittings.
6. Threads on the gland are relieved to the base of thread to minimize stress concentration.
7. Female threads on valves and fittings are relieved at base of thread.
8. All essential parts are 41455 heat treated to 100,000 p.s.i. minimum yield with 18% minimum elongation.

BULLETIN 455 GIVES COMPLETE DETAILS . . .
IT'S YOURS FOR THE ASKING.

SPECIALISTS IN

LABORATORY AND PILOT PLANT HIGH PRESSURE EQUIPMENT

AUTOCLAVE ENGINEERS, INC.

860 EAST 19TH ST. • ERIE, PENNSYLVANIA

CLEAN SMALL TUBES FAST

With ROTOJET® Junior Tube Cleaners you can clean tubes as small as .495" I.D. quickly and economically. Very little headroom is required for either vertical or horizontal tubes. Tube bundles can be cleaned without removal from shell.

The unusual power developed by the ROTOJET Motor is due to its simple design and exclusive Rotocentric (egg-shape) bore cylinder. A shaft and a blade are the only moving parts. Positive contact between blade and cylinder is always maintained. No leakage. No stalling at low speeds. Water-driven motors are also available.

Try ROTOJET Junior, and you will never go back to heavy, slow, external type cleaners costing many times more.

in
★ BOILERS
★ CONDENSERS
★ EVAPORATORS
★ SUPERHEATERS
and other
★ TUBULAR APPARATUS

S32 ROTOJET Junior Air-driven Motor, universal joint, cone cutter

C324 ROTOJET Junior Water-driven Motor, univ. joint, pivot head

C439 ROTOJET Junior Air-driven Motor, universal joint, drill head.

C434 ROTOJET Junior Air-driven Motor, flexible coupling, expanding brush.

SEND FOR ROTOJET JUNIOR BULLETIN

ELLIOTT COMPANY-ROTO DIVISION
149 Sussex Avenue • Newark, N. J.

BOSTON ONE-DAY MEETING

(*Continued from page 68*)

No Mediocrity

During the spirited panel discussion that followed the more formal session, a hot debate developed over the practice of some companies in hiring men known to be without executive potential, earmarking them for subordinate jobs from the start. General opinion finally resolved on the premise that a company should hire all men with the idea of making them executives, knowing that enough will stop on the way to adequately fill subordinate positions.

The meeting was concluded at a dinner where Barnett F. Dodge, A.I.Ch.E. president, spoke about his experiences with chemical engineering training in Europe. This training, Dodge felt, is not yet up to American standards but Europe is eager to catch up and may soon do so.

An outstanding European authority on chemical engineering, Professor Hans Kramer of the Technical University, Delft, will lecture at Minnesota Univ. during the spring quarter.

Professor Kramer, at Minnesota on funds provided by Minnesota Mining & Manufacturing, will conduct a course in fluid flow, heat and mass transfer phenomena, conduct seminars on his various research interests for advanced students and representatives of industry, and generally provide an opportunity for Midwest industrialists to become familiar with modern European engineering thinking.

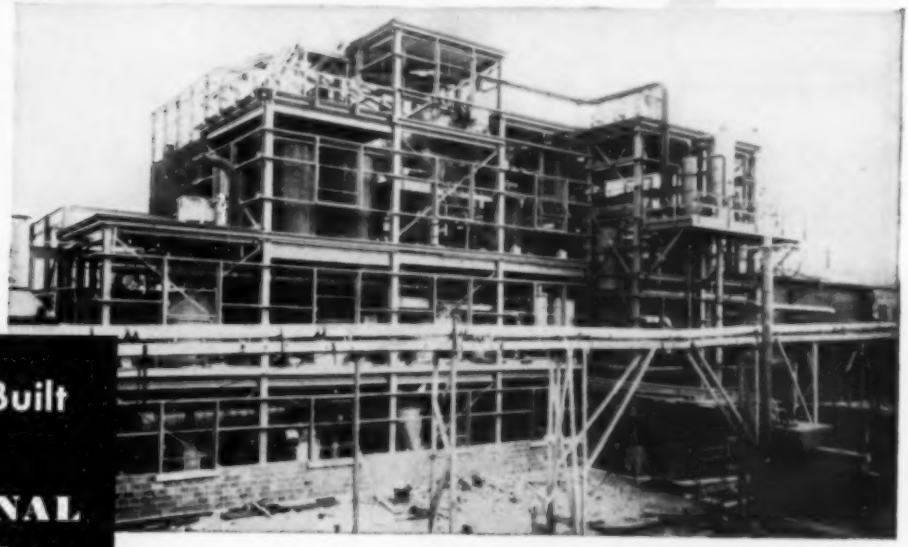
A wealth of chemical production and processing ideas is contained in **a new Government publication,** *Chemical Products and Processes,* issued jointly by the Dept. of Commerce and the Small Business Admin. The new book contains 1,350 abstracts or brief descriptions of Government-owned inventions in the chemical field.

Purpose of the volume is to encourage industry, particularly small business, to take advantage of the results of Government sponsored research. Ordinarily, of course, these patents are available on a royalty-free basis.

Patents are listed under 19 industrial-use classifications. Each listing gives the abstract, title and number of patent, name of inventor, and Government agency administering the patent.

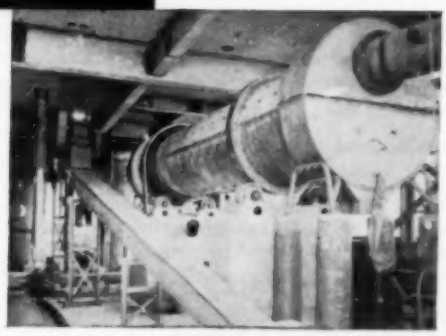
The book sells for $3 from the Office of Technical Service, Dept. of Commerce.

MODERN KOH PLANT



Designed and Built for INTERNATIONAL MINERALS & CHEMICAL CORPORATION Niagara Falls, N. Y.

for Inorganic Chemicals Manufacture



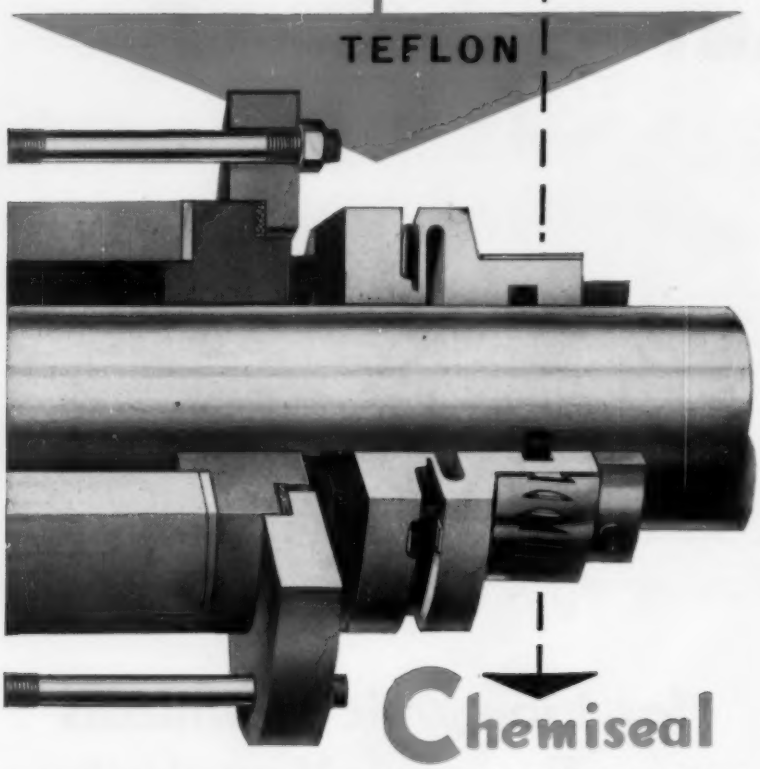
The best impression of the finished plant can be obtained at this stage of the project with the "heart of the plant" yet visible. Our engineering and construction work on this project have been completed and the plant is now in successful operation.

Engineering Services include Design and Construction of Complete Process Plant Projects and Individual Process Units, Process Evaluation, and Economic Studies.

BADGER MANUFACTURING COMPANY

230 BENT STREET, CAMBRIDGE 41, MASS. 60 EAST 42nd STREET, NEW YORK 17, N.Y.

point of interest
to **pump** users . . .



Chemiseal
MECHANICAL SEAL

● Chemiseal Mechanical Seals last longer and give unsurpassed performance in a wide variety of chemical services.

Three years of actual field experience has proven it—handling acids, alcohols, alkalies, hydrocarbons; clear, abrasive and tarry materials.

Features: Seal rotates with shaft. Only bearing surface is between precision ground rotating and stationary faces. Combines chemically impervious TEFLON with a balanced bellows design.

Low friction load on shaft. Lower power cost.

No scoring of shafts. Even shafts already scored can be satisfactorily sealed.

Pressures at seal up to 100 psi at 75°C or 75 psi at 100°C.

Sizes from ⅜" to 2⅛". Maximum length 2¾". Other sizes for special applications.

Write for Bulletin No. MS-954.

UNITED STATES GASKET COMPANY
CAMDEN 1, NEW JERSEY

USG

FABRICATORS OF FLUOROCARBONS & OTHER PLASTICS
Representatives in principal cities throughout the world

INDUSTRIAL NEWS

Now it's tin under the sea. Barriers are being broken every day in the endless search for raw materials to feed industry, and now the report comes from Malaya that the search for new tin deposits is being carried to the floor of the sea off the coast of Selangor. With the Communists slowly losing ground in Malaya, industry is pushing its search for vital tin throughout the area, even beneath the sea.

New development laboratories will be established by Celanese Corp. at Charlotte, N. C. The first section of the project is expected to go into operation in 1955. The laboratories will serve as a link between the company's Summit, N. J., laboratories and its production plants.

A headquarters move from Denver to New York City by Shell Chemical's Agricultural Chemicals Division was announced recently. The Division is the sales organization for Shell's insecticides and soil fumigants. New offices are at 460 Park Avenue, New York.

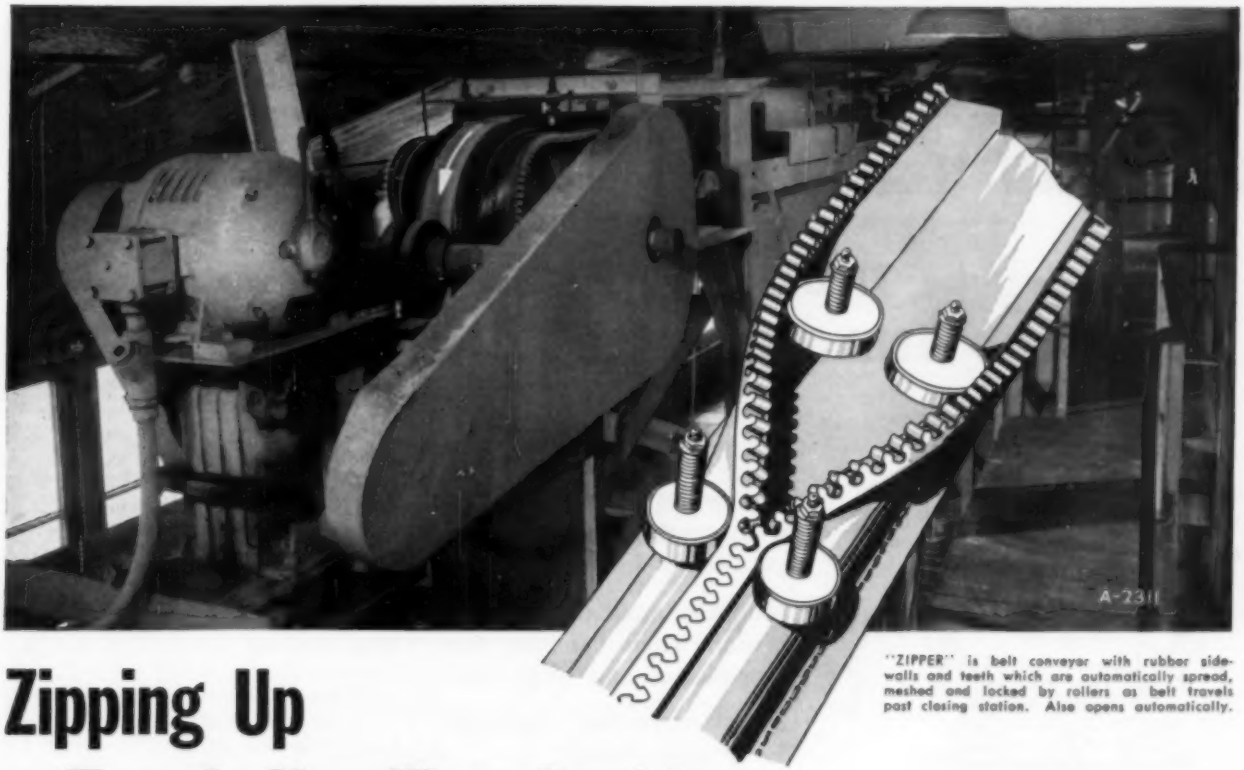
The chemical industry set **a new all-time safety record** in 1954. Lost time accidents in the industry, as recorded by the General Safety Committee of the Manufacturing Chemists' Association, amounted to 3.27 per million man-hours worked. This was the lowest figure in the history of the industry and an 11% improvement over 1953.

At the same time, accident severity rate declined to 0.49 per thousand man-hours worked, a reduction of 40% over 1953.

Looking at these figures, S. M. MacCutcheon, Dow Chemical, chairman of the safety committee, observed that, "the average chemical plant worker is safer on the job than off."

Chemical industry accident rate is less than one-third of the 11.50 per million man-hours worked preliminary figure reported for all manufacturing for 1954 by the Bureau of Labor Statistics. Now ranked as one of the safest industries in the country, the chemical industry has reduced its accident frequency rate 57% since 1946.

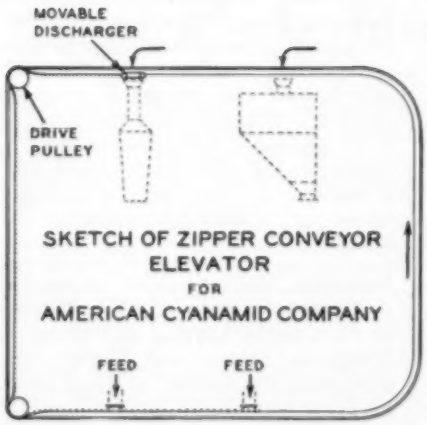
Fruit of long research and development, carried out in secret even under German occupation, is **Soceite Rhone-Poulenc's (France)** entry into commercial production of a complete line of **silicones.** In a recently completed $3 million plant near Lyon, the company is producing the silicones to meet a growing European demand.



"ZIPPER" is belt conveyor with rubber sidewalls and teeth which are automatically spread, meshed and locked by rollers as belt travels past closing station. Also opens automatically.

Zipping Up a Tough Handling Problem

S-A "Zipper" Conveyor-Elevator for Ammonium Chloride Ends Corrosion Troubles . . . .



For a long time, handling of ammonium chloride had been a difficult and expensive operation for American Cyanamid Company at its Bound Brook, New Jersey plant.

Because ammonium chloride has a very corrosive effect upon ferrous metal, dust escaping during handling could cause serious damage. At the same time, ordinary enclosed conveying systems were similarly subject to corrosion troubles. An S-A "ZIPPER" Conveyor-Elevator provided the economical answer.

Since the "ZIPPER" Conveyor-Elevator is made of rubber it is immune to corrosion and because it zips closed like a conventional slide fastener, corrosive dust cannot escape. The ammonium chloride actually travels through a sealed rubber "pipe line" that moves with the load. The ammonium chloride is fed to the S-A "ZIPPER" at two points. It is lifted in the sealed "ZIPPER" and carried to storage. Here a movable discharger, spotted by a hand winch, discharges the belt by gravity into either of two bins. At both feed and discharge, the only points in the "ZIPPER" system where the ammonium chloride comes into contact with metal, stainless steel chutes and supporting rollers are used. Corrosion problems have been practically eliminated.

If you have a bulk handling problem where corrosion, degradation, dust or economical adaptation to limited space or plant layout is a consideration, see what an S-A "ZIPPER" Conveyor-Elevator system offers you. Write and we'll arrange a survey—or send for Bulletin No. 349.

SINCE 1901 S-A STEPHENS-ADAMSON MFG. CO.

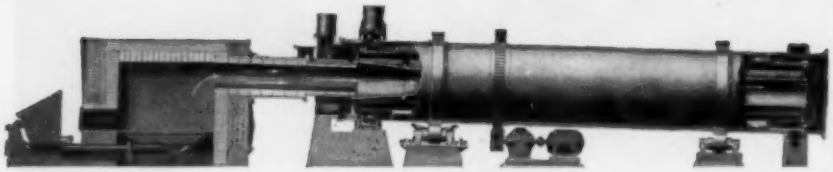
STEPHENS-ADAMSON MFG. CO.

57 Ridgeway Avenue, Aurora, Illinois • Los Angeles, Calif. • Belleville, Ontario

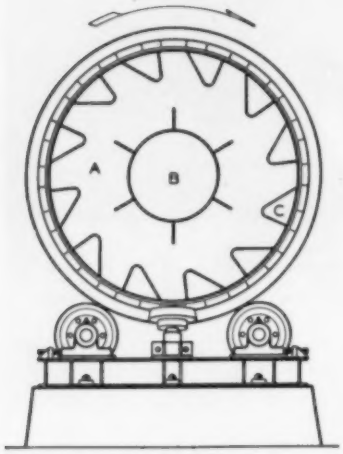
Engineering Division
Specialists in the design and manufacture of all types of bulk materials conveying systems.

Standard Products Division
A complete line of conveyor accessories including centrifugal loaders—car pullers—bin level controls—etc.

Sealmaster Division
A complete line of industrial ball bearing units available in both standard and special housings.



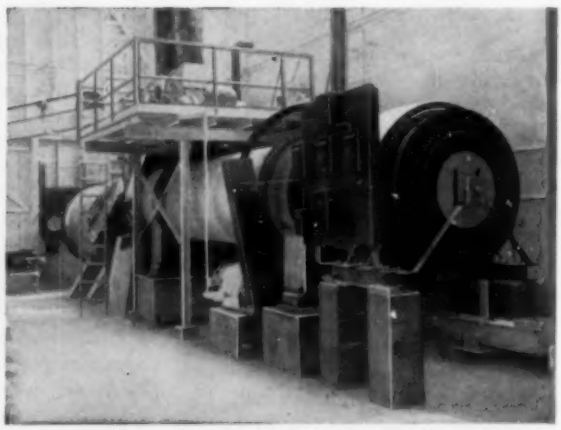
Ruggles-Coles **INDIRECT-FIRED DRYERS AND HEATERS . . .**



Cross section of dryer, "A" is the completely isolated space in which the material is dried. "B" is the inner hot gas passage. "C" represents the V-ducts for the gas return.

- Dry without contamination from combustion gases, regardless of fuel.
- Minimize auxiliary dust collection when handling fine precipitates and filter cake.
- Heat pulverized materials for process work.
- Collect vapors at high concentration.
- Available fabricated with heat and corrosion-resistant metals.

Write for complete specifications. Ask for Bulletin AH-438-40.



Ruggles-Coles Indirect Heat Dryer handling 200 mesh talc.

HARDINGE
COMPANY, INCORPORATED

YORK, PENNSYLVANIA · 240 Arch St. · Main Office and Works

New York · Toronto · Chicago · Hibbing · Houston · Salt Lake City · San Francisco

Key to **expansion program at Shea Chemical Corp., Baltimore,** is planned new phosporous furnace (capacity: 40 million pounds/year) doubling production of sodium phosphates as well as elemental phosphorous.

The program, to be on stream by 1956, includes the furnace at Columbia, Tenn.; rock washing and preparation plant at same place; sodium phosphate and phosphoric acid plant at Dallas, Tex.; and enlargement of present Adams, Mass., facilities.

Cost: $5 million plus. Result: Shea becomes one of the largest producers of elemental phosphorous and phosphorous products.

International helping-hand is being extended by Diamond Alkali to Netherlands chemical industry. A four-man "design-aid team" from Diamond's technical group is now in The Netherlands working with Dutch engineers to complete equipment and process design for the construction of a new 51 million guilder soda ash plant, the first of its kind in The Netherlands.

Designed to further Netherlands commercial development, the project is financed jointly by private, semi-private, and state funds.

When construction is nearly complete, in 1957, Dutch engineers will come to Diamond in America for process training.

Water-short Middle-Eastern areas are finding a relatively new source of electric power in **"water-easy" combustion gas turbine power plants.** A 5000 KW unit requires only 40 gallons of water per minute—about 1/15 of that required by a comparable steam-electric unit.

The unit should be specially applicable in the rich oil areas since it can burn "flare gas" now largely wasted in the oil fields.

Proposed National Fire Protection Association pamphlet on **"The Control of Flammable Liquids and Gases in Manholes, Sewers and Similar Underground Structures"** is being circulated for comment.

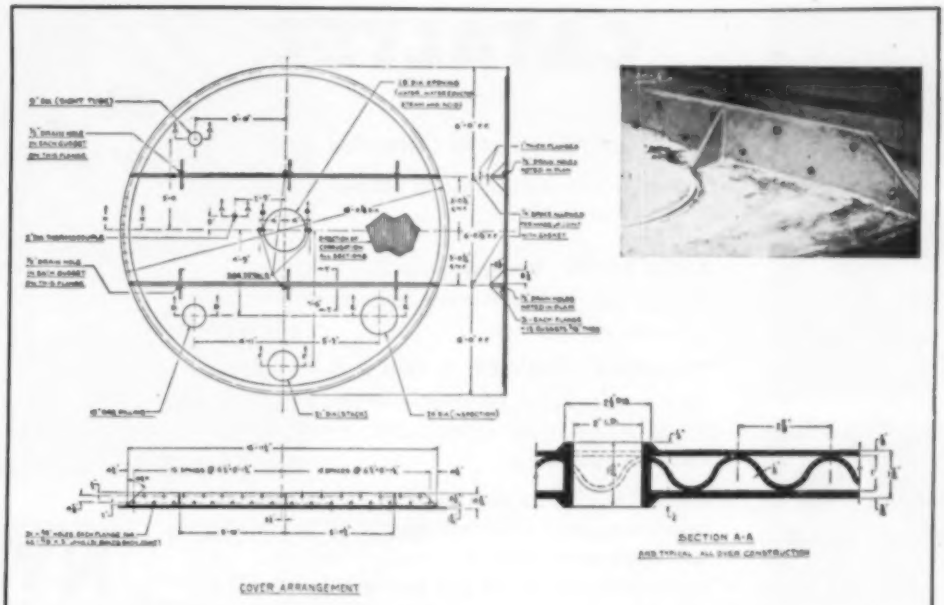
The valuable and informative publication is available on request from NFPA office, 60 Batterymarch Street, Boston.

First oil produced in Brazil outside the Bahia basin, a new gusher in the Amazon Basin, threw strong light on Brazil's rapidly expanding oil industry. Three new refineries have started operation in the last three months and by the end of 1955 total production should be up to 110,000 bbls./day.

consult HAVEG . . . America's first molder of corrosion-resistant plastic equipment

P-G TANKS for metal finishing withstand acid attack, are non-conductors of electricity, can take hard knocks.

P-G FUME DUCT is molded in- to complete fume removal systems. Duct is easily installed, does not require elaborate supports.



COVER ARRANGEMENT

SECTION A-A

HAVEG BUILT THIS P-G COVER FOR AN ACID STORAGE TANK. It replaced a wooden one with a service life of less than a year. A special corrugated reinforcement (see Section A-A) also of P-G, increased the cover's strength, reduced the weight. From design to installation, Haveg engineers worked closely with the plant engineers, made sure by return inspection that true value had been received. In fact, the customer recently ordered another P-G cover for an adjacent tank in the same service.

FOR COOLING TOWERS • FUME DUCT • TANKS • COVERS • LININGS • PIPE

of P-G laminated polyester glass

Both users and manufacturers of cooling towers, and similar structures subject to corrosive liquids and gases, can profit by relying on the accumulated engineering skill of the Haveg Corporation, which is now making polyester glass laminated plastic equipment.

Polyester glass is lightweight, low-cost, easy to fabricate and install. It resists many corrosives. Haveg P-G (polyester-glass) products are satisfactory for continuous operation at temperatures about 200°F., and for intermittent service as high as 240°F.

Molding plastics into corrosion-resistant equipment is not a new venture for Haveg. Over twenty years ago Haveg introduced a new plastic material . . . Haveg . . . made from acid-digested asbestos mixed with special Haveg resins. Haveg has been made into the biggest molded plastic tanks in the world, into a 200′ high fume stack, into giant petrochemical installations.

Like any other construction material, Haveg 41 and 60 and the new P-G materials sometimes present problems in design, manufacture, installation, or economics of selection. In the end, the purchaser must rely on the experience and reputation of the supplier. So Haveg makes these promises:

1. Polester glass will be recommended and supplied only after complete testing and full consultation with your plant engineers.

2. Haveg will use its broad experience in fighting corrosion to tell you if P-G is the best material. A reference file of installations plus systematic progress reports where available will be a valuable source of information.

Haveg P-G is new. It promises good dividends in many applications. But it calls for close cooperation between Haveg and the user. Call the Haveg sales engineer listed. Tell us your problem . . . together we will find if Haveg P-G fits your needs!

ATLANTA, Exchange 3821 • CHICAGO 11, Delaware 7-6088
CINCINNATI 36, Sycamore 2600 • CLEVELAND 20, Washington 1-8700
DETROIT 39, Kenwood 1-1785 • HOUSTON 4, Jackson 6840
LOS ANGELES 14, Mutual 1105 • SEATTLE 7, Hemlock 1351
WESTFIELD, N. J., Westfield 2-7383

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FACTORY: WILMINGTON 8, DEL. • Wilmington 3-8884
A SUBSIDIARY OF CONTINENTAL-DIAMOND FIBRE CO.

caused by trapped air or gases.

HOW YOU BENEFIT WITH GIRDLER CATALYSTS

Increuses ammonia output 40% with

GIRDLER G-29 CATALYST

at Mississippi Chemical Co., Yazoo City, Miss.

APPLICATION: Promoting reaction of steam, air and natural gas in reforming furnaces to produce ammonia synthesis gas.

TECHNICAL SERVICE of Girdler demonstrated that a switch to its newly developed G-29 would result in an appreciable increase in the ammonia production.

RESULTS: Greater activity of G-29 enables customer to increase ammonia production about 40% when required. This is accomplished with no appreciable increase of fuel consumption per unit of ammonia produced.

Find out how Girdler Catalyst Technical Service can help *you!* Write for Bulletin G-260.

the GIRDLER Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY
LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION: New York, San Francisco
VOTATOR DIVISION: New York, Atlanta, Chicago, San Francisco
In Canada: Girdler Corporation of Canada Limited, Toronto

Phenol arrives here at National's Hopewell monomer plant by tank car where it is combined with synthesis gas and ammonia from Allied's adjacent Nitrogen Division plant to form the caprolactam from which nylon-6 is being produced. The actual nylon is made at National's nearby polymer plant in Chesterfield.

NYLON-6

Production of nylon-6 (caprolactam-nylon), first major thermoplastic produced by Allied Chemical & Dye, is a chemical engineering achievement of major proportions. By developing a workable process for full scale production of pure caprolactam from phenol and hydrogen, Allied has made it possible to produce the new nylon on a commercial scale for the first time in this country.

Especially valuable as a molding compound, caprolactam-nylon-6 is produced from basic chemicals supplied by Allied's Barrett and Nitrogen Divisions, actually manufactured by the National Aniline Division, and sold by the Barrett Division. Interest in nylon-6 centers in its ease of extrusion and its controllable crystalline nature, which make it possible to form high strength nylon film of exceptional clarity, toughness, and abrasion resistance. Axial orientation of the new nylon, called Plaskon Nylon 8200 by Allied, increases the physical properties which will allow much thinner films to be used in the packaging field.

Phenol and Hydrogen

Barrett Division makes phenol from benzene, petroleum gas, and air, ships it by rail to the Hopewell, Va., monomer plant of National Aniline Division. At Hopewell it is reduced to cyclohexanone by synthesis gas obtained by a side

FIRST COMMERICAL PRODUCTION

Heart of the matter—Successful commercial process for making caprolactam, from phenol and hydrogen, pure enough to polymerize to nylon.

stream from Nitrogen Division's ammonia plant. Meanwhile, ammonia from the Nitrogen Division, sulfur, and air are being reacted to form hydroxylamine which is reacted with the cyclohexanone and leads to cyclohexanone oxime and caprolactam.

The caprolactam, of high purity, is polymerized at the new polymer plant of National Aniline Division at Chesterfield, Va., into nylon-6. Barrett Division returns to the picture as salesman for the new nylon.

Easy Molding

Nylons as a class have always presented a peculiar problem to molders. Below certain temperatures they are too solid to extrude or injection mold. Above the lowest workable temperature they become fluid so rapidly that containment is a problem. Nylon-6 on the other hand has a relatively high molten viscosity, to great extent eliminates the problem of leakage from nozzles and joints, is even adapted to difficult blow-molding.

Maximum impact strength or toughness with minimum mold shrinkage is obtained in nylon-6 at low mold temperatures. As mold temperatures increase the new nylon becomes more rigid, but even at 200 degrees F. it is not brittle.

A unique characteristic of nylon-6 is its controllable crystalline structure which allows the molder or extruder to vary the finished product's final physical properties in thin sections.

In addition, nylon-6 does not decompose or liberate gas during the molding or extrusion cycle. This allows the production of very thick sections or very large pieces with a minimum of voids caused by trapped air or gases.

Allied's new nylon can be cold-colored after molding, if only a few millimeters of color depth are needed. If more depth is required for fully colored pieces, a simple blending of color with the charge before molding will do the job. For very deep colors a master batch and blending operation can be used.

Allied sees many possible uses for the new nylon, but it is already looking beyond this first product of its successful caprolactam production and polymerization. An active research and development program is already underway on nylon-6 itself, and on future nylon plastic applications.

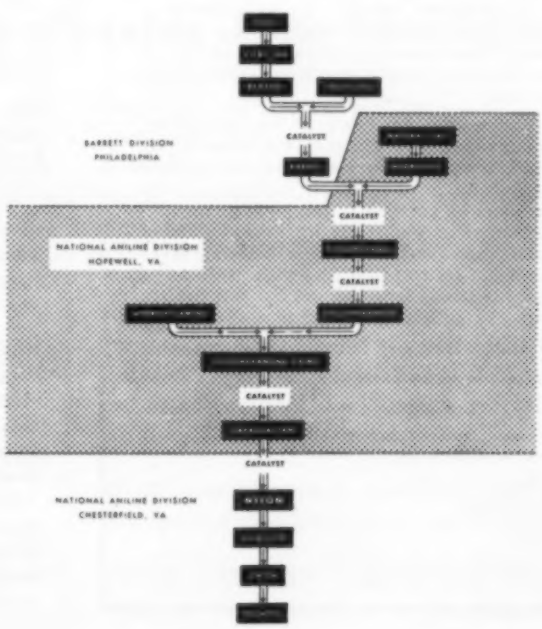
Highly Versatile

The importance of nylon-6 lies partly in the high use-value of nylon. Although a relatively expensive plastic, nylon has advantages and a versatility that make it desirable as a commercial product.

For the first time on production equipment, nylon bottles have been made using Allied's nylon-6. Because of the strength, impact resistance, and chemical resistance of the new nylon, it is possible that it may open the field of low pressure spray type unbreakable bottles for the cosmetic industry. It may also open new fields in the packaging of chemicals not available previously in plastic containers.

Process Counts

But the real importance of Allied's new nylon lies more in the process by which the pure caprolactam was produced on a commercial scale. Now that this has been successful, new developments in the caprolactam nylon field are sure to grow rapidly.



So SIMPLE that "Specials" are Likely to be Standard!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol

MAGNETROL

The World's Most Dependable

LIQUID LEVEL CONTROL

Because of the utter simplicity of Magnetrol's magnetic operating principle, standard models can be easily adapted to meet any special requirements for pressure, temperature or corrosive liquids . . . and usually at little extra cost. This Magnetrol versatility has solved all kinds of tough level control problems . . . and given our engineers wide application experience that can be invaluable to you.

Magnetrol is so simple that failure is all but impossible! Using only permanent, unfailing magnetic force for its operation, there's nothing to wear out . . . no diaphragms or bellows to stiffen and rupture . . . no electrodes to short or corrode . . . no packing to bind or leak. Magnetrol is practically maintenance-free! Magnetrol units are available for controlling level changes from .0025-in. to 150-ft. . . . with multi-stage switching when desired. Send coupon for full details.

MAGNETROL, Inc.

Send Coupon For Full Details

MAGNETROL, Inc., 2126 S. Marshall Blvd., Chicago 23, Illinois

Please send me catalog data and full information on Magnetrol Liquid Level Controls.

Name_____

Company_____

Address_____

City_____ Zone____ State_____

CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on admissions.

These names are listed in accordance with Article III, Section 8, of the Constitution of A.I.Ch.E.

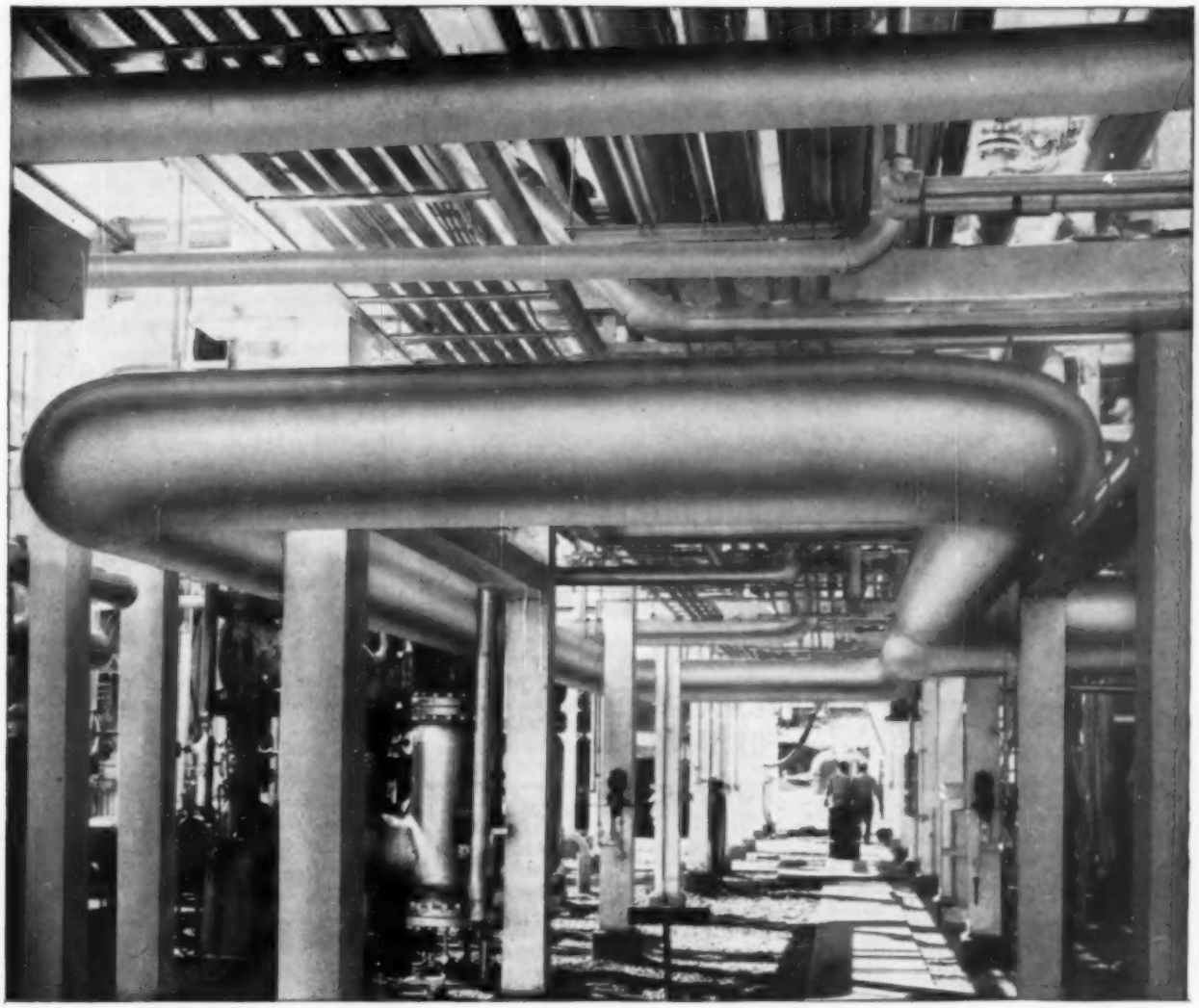
Objections to the election of any of these candidates from Members will receive careful consideration if received before June 15, 1955, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Anderson, John W., *Neshanic Station, N. J.*
Anderson, Julius A., *Barberton, Ohio*
Baker, R. A., *Los Angeles, Calif.*
Berg, Ralph R., *Menlo Park, N. J.*
Boylan, D. R., *Ames, Iowa*
Brusco, Richard J., *Westfield, Mass.*
Burris, Leslie, Jr., *Lemont, Ill.*
Calder, Bruce L., *Toms River, N. J.*
Castler, Leo A., *Compton, Calif.*
Chow, Wen M., *Bound Brook, N. J.*
Christianson, Thomas K., *Marinette, Wis.*
Culbertson, Leroy, *Bartlesville, Okla.*
Eastwood, S. C., *Woodbury, N. J.*
Edlin, Frank E., *Wilmington, Del.*
Elliott, Jack F., *Pasadena, Tex.*
Etherington, Lewis D., *Cranford, N. J.*
Foster, M. H., *South Charleston, W. Va.*
Greathouse, Lucien H., *New Orleans, La.*
Gudheim, Arne, *Petersham, Mass.*
Hightower, Charles T., *New York, N. Y.*
Holstein, Otto A., *Springfield, Pa.*
Hulett, Daniel G., *Charleston, W. Va.*
Hungerford, Richard C., *Berkeley, Calif.*
Hunn, Robert J., *Media, Pa.*
Judson, James H., *Whiting, Ind.*
Kendra, Edward J., *Frederick, Md.*
Kraybill, Richard R., *Rochester, N. Y.*
Landrum, Thomas C., *Baton Rouge, La.*
Levene, Harold D., *El Paso, Tex.*
Linden, Henry R., *Franklin Park, Ill.*
Martin, M. W., *San Marino, Calif.*
McFarland, John W., *Charleston, W. Va.*
McLain, Cecil H., *Houston, Tex.*
Miller, James R., *Baytown, Tex.*
Mozley, James M., *Wilmington, Del.*
Myers, Jacob W., *Toledo, Ohio*
Nelson, Henry R., *Gibbstown, N. J.*
Parker, J. L., *Tulsa, Okla.*
Prahl, Walter H., *Buffalo, N. Y.*
Romell, Robert F., *Cincinnati, Ohio*
Smith, Harry D., *Houston, Tex.*
Stevens, Richard F., *Kirkwood, Mo.*
Stock, Robert P., *Cuyahoga Falls, Ohio*
Summers, C. R., Jr., *Philadelphia, Pa.*
Tierney, John A., *Charleston, W. Va.*
Tomlinson, C. W., *Pasadena, Tex.*
Weber, James H., *Lincoln, Neb.*
Woebcke, Herman N., *Ladue, Mo.*
Wolfe, J. S. Brooks, *Akron, Ohio*

Associate

Adams, Harry S., *Redondo Beach, Calif.*
Aikman, A. R., *Ridgefield, Conn.*
Baldwin, Richard Harold, *Chicago, Ill.*
Bayliss, Jack B., *Memphis, Tenn.*
Bieber, Herman, *Brooklyn, N. Y.*
Borell, Robert W., *Wilmington, Del.*
Campbell, Willis H., *Monsanto, Tenn.*
Catanach, Charles B., *Woodbury, N. J.*
Cherry, Ray, *Dickinson, Tex.*
Clark, Harold B., *Urbana, Ill.*
Colgan, Joseph D., *Ozone Park, N. Y.*
Craig, James W., *St. Louis, Mo.*
Dehmlow, Louis H. T., *Chicago, Ill.*
Del Gobbo, Nello, *Florence, Ala.*
Dew, John Norman, *Ponca City, Okla.*
Engelson, George E., *Kenberma, Mass.*
Everett, Richard E., *Wilmington, Del.*
Feldman, William J., *Argo, Ill.*
Gelder, Everett W., *Lockport, Ill.*
Haase, Alfred E., *Fanwood, N. J.*
Hancock, B. W., *Sheffield, Ala.*
Haughton, Milton A., *Gibbstown, N. J.*
Hersh, Charles K., *Chicago, Ill.*
Hooper, Blake H., *Chicago, Ill.*
Humbert, John W., *Madison, Wis.*
Humm, David M., *Notre Dame, Ind.*
Jenick, Edward C., Jr., *Bayport, N. Y.*



Less heat loss at joints with single-layer Unibestos® Pipe Insulation

Tests prove that Unibestos single-layer pipe insulation actually provides greater protection than other nonfibrous *double-layer* insulations which cost more to install. Unibestos is made of Amosite—the long-fibered African asbestos. These fibers interlock with one another to prevent heat loss at horizontal and longitudinal joints.

While most insulating materials show a pronounced shrinkage at high temperatures, Unibestos has no measurable shrinkage at 1200°F. It will not powder, pulp or wash off, even under heavy moisture conditions, and when dry, Unibestos resumes its original thermal and physical characteristics.

EASY to install . . . easy to remove.

Unibestos can be cut, mitered and handled easily. The fabrication of insulation for tees, valves, flange covers, etc., is a fast, low-cost operation. Because of its unusual strength and durability Unibestos can be removed and replaced with little or no loss of material.

STANDARD PRODUCTION SIZES

Unibestos Pipe Insulation is regularly made in 3-foot lengths for pipe sizes from ½″ through 24″, in standard thicknesses through 5″. Unibestos Block Insulation is made in 6″, 12″, 18″ or 36″ widths and in thicknesses from 1″ through 3″ in ½″ increments.

For complete information, write for descriptive Bulletin 109C

UNARCO

UNION ASBESTOS & RUBBER COMPANY

1111 West Perry Street • Bloomington, Ill.

Typical of Proctor & Schwartz low-cost, easy-to-erect spray drying systems, is this installation of the Georgia Kaolin Co. at Dry Branch, Ga. The Georgia Kaolin dryer discharges a high-density, free flowing product that is ready for immediate packaging or shipment.

Flexibility of Operation—Because of its simplified construction and the small quantity of product retained in the system, the dryer offers wide flexibility and adjusts to specification instantly.

Automatic Control—All operations are automatic with mechanical feeds.

Profits go up—The dryer not only combines high thermal efficiency with the convenience of outside location, but the initial cost of equipment per pound of dried clay is low, and operating costs are drastically reduced.

Customer Confidence—These spray dryers are a direct result of the confidence that customers such as Georgia Kaolin have placed in Proctor & Schwartz engineering and manufacturing facilities. This faith has been justified through the many innovations and refinements Proctor & Schwartz have made in spray drying, and which now give higher quality output and greater drying efficiency on the job, as guaranteed.

OTHER TYPES OF PROCTOR & SCHWARTZ DRYING EQUIPMENT • Tray Dryers • Truck Dryers • Continuous Conveyor Systems • Pre-forming Feeds • Spray Drying

PROCTOR & SCHWARTZ, Inc.

Manufacturers of Industrial Drying Equipment and Textile Machinery

Philadelphia 20, Pa.

CANDIDATES

(Continued from page 78)

Leas, George F., Ballston Lake, N. Y.
Lerner, Seymour, Oak Ridge, N. J.
Lesser, William C., Highland Park, N. J.
Levine, Zelvin, Atlanta, Ga.
Lewis, Darwin E., St. Louis, Mo.
Liu, Tung, Pittsburgh, Pa.
Loos, Robert R., Euclid, Ohio
Masten, Charles N., Pitman, N. J.
McQueen, Herbert F., Huntsville, Ala.
Mead, Radford A., Ossining, N. Y.
Mickelson, Richard W., Naugatuck, Conn.
Moore, Don R., Baytown, Tex.
Nelson, Richard Lee, Jr., Long Beach, Calif.
Oliver, Robert C., Long Beach, Calif.
Park, Ben D., Beaumont, Tex.
Poe, William Lee, Jr., Aiken, S. C.
Porter, Walter J., Jr., Baton Rouge, La.
Rao, K. Nagaraja, Minneapolis, Minn.
Rock, Samuel, Jr., Frederick, Md.
Sammarone, Dino G., Pittsburgh, Pa.
Samoden, Robert A., West Haven, Conn.
Schaer, Glenn R., Columbus, Ohio
Schreiner, Max, Jr., College Park, Md.
Segraves, William B., Baton Rouge, La.
Sinson, E. A., Gibbstown, N. J.
Smith, Fritz Arthur, Woodbury, N. J.
Smith, Gilbert A., Ashtabula, Ohio
Stoker, Donald J., Richland, Wash.
Strage, Henry Michael, Frederick, Md.
Surosky, Alan E., Fair Lawn, N. J.
Tepas, John A., Euclid, Ohio
Theobald, Earle W., Cuyahoga Falls, Ohio
Threadgill, Walter Dennis, Nashville, Tenn.
Treibel, Elroy E., Woodbury, N. J.
Vance, John M., Knoxville, Tenn.
Vollmer, Edward L., St. Louis, Mo.
Von Rosenberg, Dale U., Houston, Tex.
Voress, A. G., South Charleston, W. Va.
Walton, R. W., South Charleston, W. Va.
Wolfe, Russell M., Chattanooga, Tenn.
Zakin, Jacques L., Flushing, N. Y.
Zwiebel, Imre, Wilmington, Del.

Affiliate

Krash, Mark F., New Martinsville, W. Va.
Waggener, Richard W., Aberdeen Proving Grounds, Md.

A "finder's list" of key engineers throughout the nation is being assembled by Engineers Joint Council. The list, undertaken by EJC in cooperation with National Science Foundation, will contain some 20,000 leaders in all branches of engineering. Part of the program of the National Register of Scientific and Technical personnel, the list will contain leaders in the profession who can be relied upon to locate needed engineering talent in case of national need.

To date, 8,000 names have been collected.

The 1954 volume of C.E.P. is available on Microfilm from University Microfilms, 313 N. First Street, Ann Arbor, Mich. The price, $3.20, for all 12 issues on one roll ready for the projector.

"New" reserve of iron ore is Jones & Laughlin's claim as a result of its pilot plant operation on low-grade iron ore.

Reason: The plant has demonstrated that **non-magnetic low grade iron ores can be magnetized** and concentrated by simple magnetic separation. Next step: Increase in scale of development until full-size commercial plants will be able to deliver high-grade concentrate to J & L's blast furnaces.

With large reserves of non-magnetic taconite ores available in this country, containing some 30% iron, this development could mean the alleviation of present threat of early depletion of American iron ore deposits. With its new process, J&L claims to end with a concentrate of as much as 63% iron.

By using a fluidized solids reactor, the taconite is magnetized in much the same way as petroleum is refined in a catalytic cracker. Ground to a minus-14 mesh size, the ore is chemically reduced to magnetite while suspended in a turbulent stream of hot reducing gas. The ore is then removed from the furnace and quenched in water, producing cracks in the ore which facilitate fine-grinding and better separation of iron mineral from the silica. Following three stages of grinding and magnetic separation, the ore is concentrated in a high-grade fraction. About half the original ore is lost in the process as waste.

The final concentrate is too fine to be used in blast furnaces, and too fine to be sintered by conventional means. To overcome this problem J & L has applied pelletizing as the initial agglomerating process. This provides a material suitable for sintering into the larger particles needed by the blast furnaces.

Slightly more than two tons of Michigan crude taconite are needed to produce one ton of ore concentrate.

Shift of the chemical industry away from major metropolitan centers seems to be the trend for the future according to W. C. Foster, president, Manufacturing Chemists Association, speaking at the 30th Annual Conference of the American Industrial Development Council on April 5.

What the chemical engineer will find for his future work location is graphically illustrated by a recent list of 480 construction projects in the chemical industry. Of the 480 only 9, less than 2 per cent, are in major metropolitan centers.

This trend is bringing decentralization and "absentee ownership," but it is also bringing a greater sense of community relations and local interest.

NEW SAVINGS in your operations

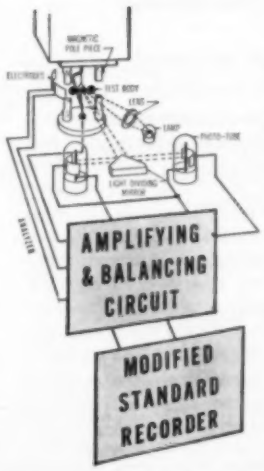
with

Arnold O. Beckman OXYGEN ANALYZERS

Pictured is the Model G2 Recording Analyzer—finest for precise oxygen measurement.

ON OPERATIONS LIKE THESE... MAKE SAVINGS LIKE THESE

PROCESSING AIR LIQUIFRACTION AND PRODUCTION OF HIGH PURITY GASES	*Better product quality with minimum oxygen or air contamination*
SAFETY PRODUCTION OF HYDROGEN, ACETYLENE, ETC.	*Control explosive atmospheres, reduce fire risks, minimize plant and personnel hazards*
PRODUCT PROTECTION RESIN KETTLES, COLOR PIGMENTS, PRODUCT STORAGE, ETC.	*Reduce oxidation, maintain product standards with controlled purge systems*



Unique Operating Principle

The various applications highlighted above are only a few of the many ways Arnold O. Beckman Oxygen Analyzers—industry's great new profit builders—are being used by progressive operators to boost profits, cut costs.

These are the *only* oxygen analyzers that *continuously* measure process streams by an advanced magnetic principle that provides *direct physical measurement of the oxygen itself*—not of some secondary relationship.

Heart of the unit, as illustrated, is a dumbbell-shaped test body suspended in a magnetic field. Sample gas surrounding this test body causes it to rotate in the field, depending upon the oxygen content of the gas. The movement of a light beam, reflected by a small mirror on the test body, is measured by simple electronic circuits... and the result indicated directly on a conventional recorder or indicator. It's simple, positive, accurate!

No chemicals—filaments—catalysts cams—complicated mechanical parts!

FEATURES OF THE G2

Many ranges: Full scale ranges 0-0.1%, 0-0.5%, 0-1% O_2 and others for low O_2 concentrations. Ranges 90-100%, 95-100% O_2, etc., for high O_2 concentrations.

Multi-Ranges: Any instrument may be supplied with two or more ranges.

Note: For ranges wider than 0-5% O_2, ask about the Model F3 Analyzer.

***Send for Helpful Free Literature** which describes this unique operating principle in detail—explains its many advantages and applications. When writing, outline your particular operations—we'll gladly supply specific information.*

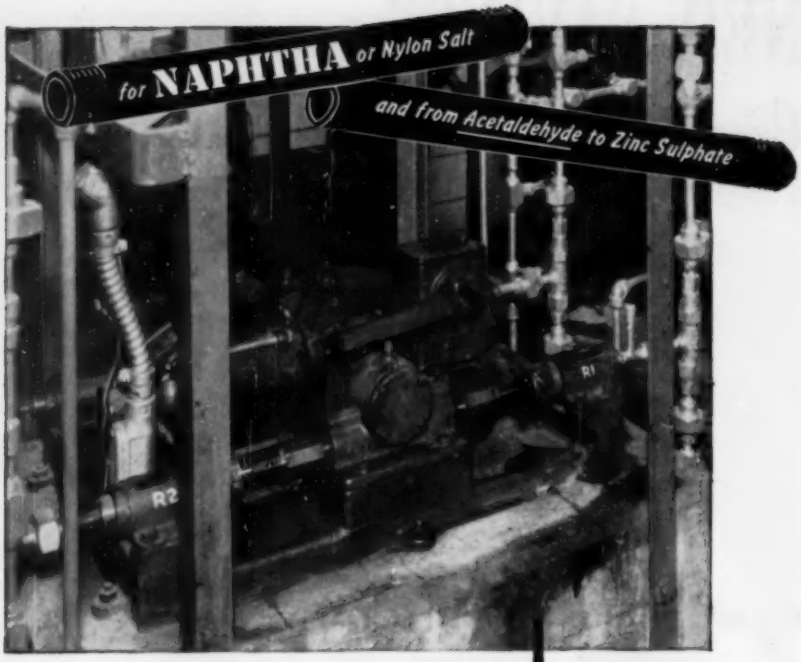
Ask For Data File 15A-55

Arnold O. Beckman INC

Instruments for Science and Industry

1020 MISSION STREET

SOUTH PASADENA, CALIFORNIA



HILLS-McCANNA
"U" Type metering / proportioning PUMPS

give TROUBLE-FREE PERFORMANCE ON TROUBLESOME FLUIDS

Built to serve dependably in an industry that is *on the move*, the Hills-McCanna "U" Pump is daily finding new services to add to a diverse group of hundreds of different types of metering and proportioning jobs. But assurance of trouble-free performance through a wide range of problem fluids is only one of several versatile features offered by the "U" Pump.

One, two, three and four feed assemblies, mounted on a common base, are available in a range of capacities from 0.10 to 24.0 gph per feed. Operating pressures are from 125 psi to 5000 psi. Variable speed drive or a choice of 30, 40, 50 and 70 strokes per minute (with stroke length adjustment from 0 to maximum) provide efficient *controlled* pumping . . . reliability and accuracy that has made the "U" Pump the *preferred* pump for research, pilot plant and production uses.

Write for Bulletin UP-54, outlining "U" Pump service . . . recommendations for over 325 applications. And ask about other Hills-McCanna metering and proportioning pumps. HILLS-McCANNA CO., 2438 W. Nelson St., Chicago 18, Ill.

HILLS-McCANNA
metering and proportioning pumps

Also Manufacturers of:
SAUNDERS TYPE DIAPHRAGM VALVES
FORCE FEED LUBRICATORS • MAGNESIUM ALLOY SAND CASTINGS

INDUSTRIAL NEWS

A greatly expanded chemical market for molybdenum developed in 1954, according to Climax Molybdenum, New York.

With the exception of the metals industry, the greatest single use for molybdenum last year was catalysis. As the race for higher and higher octane ratings in gasoline progressed, a number of new catalytic refining processes came into use with molybdenum as a preferred catalytic material. Total consumption of molybdenum as a catalyst rose from 200,000 pounds in 1953 to nearly 900,000 pounds in 1954. A further increase of one-third is expected in 1955.

As a pigment, molybdenum orange led with a consumption of nearly 800,000 pounds—highest sales on record. Rounding out the chemical-use picture was the new but growing use of molybdenum as a fertilizer in agriculture, with world consumption reaching 100,000 pounds in 1954.

The **entry of Sherwin-Williams into the polyester resin field** underlines the close connection between techniques and know-how in the paint and plastics industries.

In bringing out a complete line of the resins, used for the manufacture of reinforced plastics, Sherwin-Williams is utilizing its long experience in pigmentation, sealing and flow—all problems involved in plastics manufacture.

The company will concentrate on a "custom service" approach, although a standard line of resins will be offered under the name "Poly-Kem."

Substantial royalties in West German deals are being piled up by a growing number of American firms. The New Products Institute, Irvington-on-Hudson, N. Y., a clearing house of new products, processes and marketing ideas, has found that German firms outnumber all others in placing royalty requests. Arrangements are smoothly handled and secure, and the Germans appear anxious to take on American patents for their expanding market.

New $1.5 million nepheline syanite (feldspar and nephelite mineral, high in alumina, quartz-free) plant is now under construction for International Minerals and Chemical in Ontario, Can. Drawing on a reserve of some 30 million tons of superior quality mineral ore, the new plant will serve American and Canadian glass and ceramic industries with this important raw material.

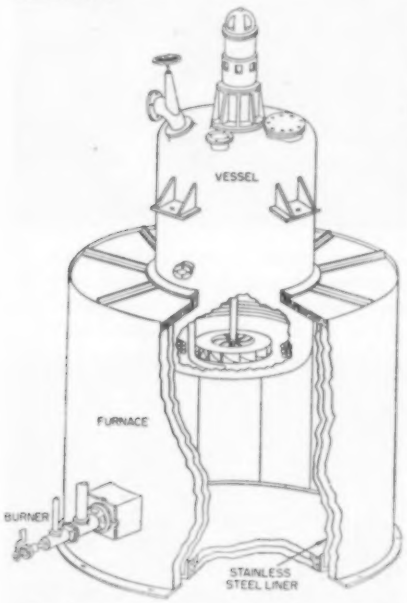
FOR RESEARCH LABORATORIES

EQUIPMENT APPLICATION

Results of three and a half years' operation indicate that **three radiant heating furnaces of a new design**, developed by Blaw-Knox for Pratt & Lambert's 7000 gallon capacity oil bodying and alkyd resin plant at Buffalo, N. Y., are proving superior to conventional direct-fired furnaces.

With an initial investment cost approximately 50% less than indirect heating systems which could provide the same necessary degree of close control over both heating and cooling, operational data has shown that the furnaces operate on at least one-third less fuel than the older, direct-fired set kettles.

Still another savings factor cited by Pratt & Lambert is a substantial reduction in labor costs, made possible through the automatic operation of the furnaces and auxiliary equipment, larger batch production, and improved housekeeping conditions.



Basis of the new design is a rapid transfer of radiant heat into the kettles without development of local hot spots and consequent discoloration of product. Heat retention is held to a minimum once fuel input is cut.

A new process, claimed to produce ferrous metal equipment that can be used wherever stainless steel properties are required, has been developed by Alloy Surfacing Co., Phila. The process, **the diffusion of chromium into ferrous metals without dimensional change,** is designed to permit ferrous metals to resist corrosion even under the most severe atmospheric, water and chemical corrosion conditions. Said to resist wear, abrasion, bending, stretching or

(*Continued on page* 84)

SPARKLER

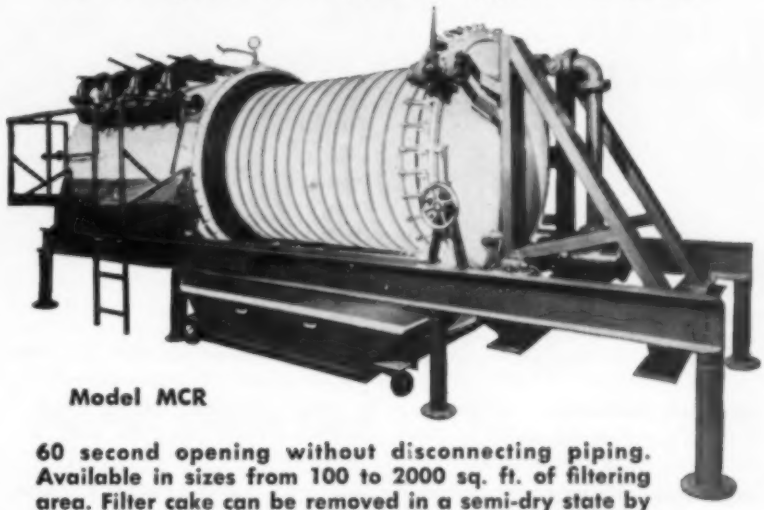
Retractable Tank

Heavy Duty Filter

1000 sq. ft. of Filtering Surface

2000 lb. Filter Cake

The largest filter of it's type ever built



Model MCR

60 second opening without disconnecting piping. Available in sizes from 100 to 2000 sq. ft. of filtering area. Filter cake can be removed in a semi-dry state by hand scraping or in some cases merely tapping the plates to let the cake fall into the portable disposal receptical.

One man can handle the complete cleaning operation in ten minutes. One movement of a handle to release head bolts, a flip of a switch and the tank moves back, stopping automatically, exposing the plates in less than 60 seconds. Pipe connections are all in the stationary head, so no disconnecting of piping is required. This gives you the fastest action, time-saving, labor-saving tank opening ever engineered in a filter.

Jet pressure spray tubes can be supplied in this filter for washing off cake or in combination with backwashing when the material filtered and sewer conditions permit this type of cleaning.

Filter tanks can be supplied in mild steel, stainless steel, Hastelloy or other metals to meet requirements.

Write Mr. Eric Anderson for personal service

Ten outstanding features

1. Large flow volume—large plate area up to 2000 sq. ft. and 1 ton cake.
2. One man fingertip operation.
3. No pipe lines to break in opening filter.
4. Filter seal of plates not broken in cleaning.
5. Self sealing cover gasket.
6. Dry cake disposal or flush down cleaning.
7. No head room required above filter.
8. Complete plate drainage.
9. Uniform precoating.
10. Quick opening cover.

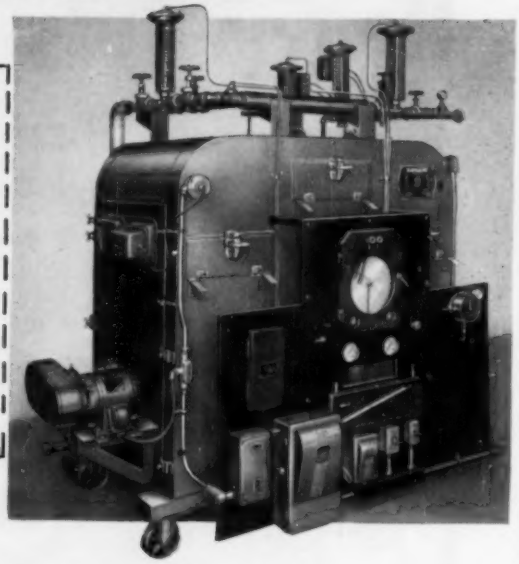
SPARKLER
MANUFACTURING CO.
MUNDELEIN, ILL.

European Plant: Sparkler International Ltd., Prinsengracht 876, Amsterdam, Holland.
Canadian Plant: Sparkler International Ltd., Galt, Ontario, Canada.

FOR RESEARCH LABORATORIES . . .
UNIVERSITY LABS . . . PILOT PLANTS

THE NEW **Portable LAB DRYER by SARGENT**

FOR OUTRIGHT PURCHASE or on a SENSIBLE RENTAL-PURCHASE PLAN



FULL SIZE — 8′-6″ high x 8′-0″ wide x 6′-7″ deep.

MOBILE — mounted on heavy-duty ball-bearing casters that lock securely into position.

FLEXIBLE, VERSATILE — for steam or electrical heating of air stream. Material tested in trays, suspended from poles, on rolls, or any combination.

INSTRUMENTED FULLY and completely — ready to go to work for you without delay.

Modeled on the famous Sargent-developed, designed and built, research dryer used in Sargent's own drying research laboratory.

Here are some of the industries with proven applications of Sargent Drying:

Building Materials
Chemicals and Pharmaceuticals
Explosives
Feed Stuffs
Fertilizers
Fruits and Berries
Inks and Pigments
Metal Parts
Nuts
Paints
Paper and Paper Products
Plastics
Rubber — reclaimed, Synthetic, Natural
Textiles — fibres, yarn, cloth
Tobacco
Vegetables
Waste Sludges

A telephone call to the nearest Sargent representative, or direct to us, will produce any additional information you want—AND fast action!

C. G. SARGENT'S SONS CORPORATION
INDUSTRIAL DRYERS DIVISION
Graniteville, SINCE 1852 Massachusetts

CINCINNATI 15 — A. L. Merrifield, 730 Brooks Avenue
CHARLOTTE, N.C. — W. S. Anderson, Carolina Specialty Co.
PHILADELPHIA 19 — F. E. Wasson, 519 Murdock Road
TORONTO, CANADA — Hugh Williams, 47 Colburn Street

EQUIPMENT APPLICATION

(*Continued from page* 83)

twisting, the metal is easily worked and fabricated.

The company recommends use of its product anywhere stainless steel is called for.

Acid and caustic resistant Dynel valve and flange covers have just been adopted by California Oil Refining Co.'s alkylation unit at Perth Amboy, N. J.

Dynel, produced by Union Carbide, is a strong, chemically resistant fabric. In the form of covers it is finding growing favor as a replacement for the more cumbersome and less flexible lead covers. Strong enough to contain sprays resulting from gasket or packing failures in pressurized lines, Dynel covers are also flexible enough to permit complete operating freedom of covered valves.

Designed to operate at temperatures up to 550 degrees F., the **new 3500 gal. glass-lined kettle** made by Pfaudler for Argus Chemical Corp., Brooklyn, is believed to be the largest of its type in this country.

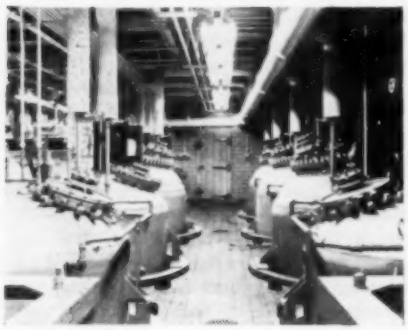
With an automatic pressure-less high temperature system engineered by American Hydrotherm, the kettle utilizes Aroclor 1248, a Monsanto fire-resistant heat transfer fluid, and is part of Argus' modernization and expansion program. The kettle will be used for the manufacture of heat and light stabilizers for polyvinal chloride.

The heat source is an International-LaMont thermal liquid forced circulation heater of 3 million B.t.u./hr. capacity.

Explosion-proof fluorescent lighting has been installed at Armour and Company's new Kankakee, Ill., pharmaceutical center.

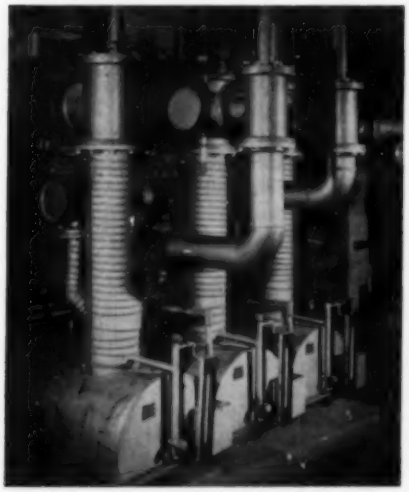
Installed by Crouse-Hinds, the new lighting system is designed to cut down the hazards of handling the highly flammable solvents required in Armour's extraction operations.

Manufacturing powerful biologicals, such as insulin, thyroid, ACTH, pituitary hormones, and gamma globulin, from tons of animal glands and organs, Armour exercises extreme caution in working with the necessary explosive solvents, such as ether.

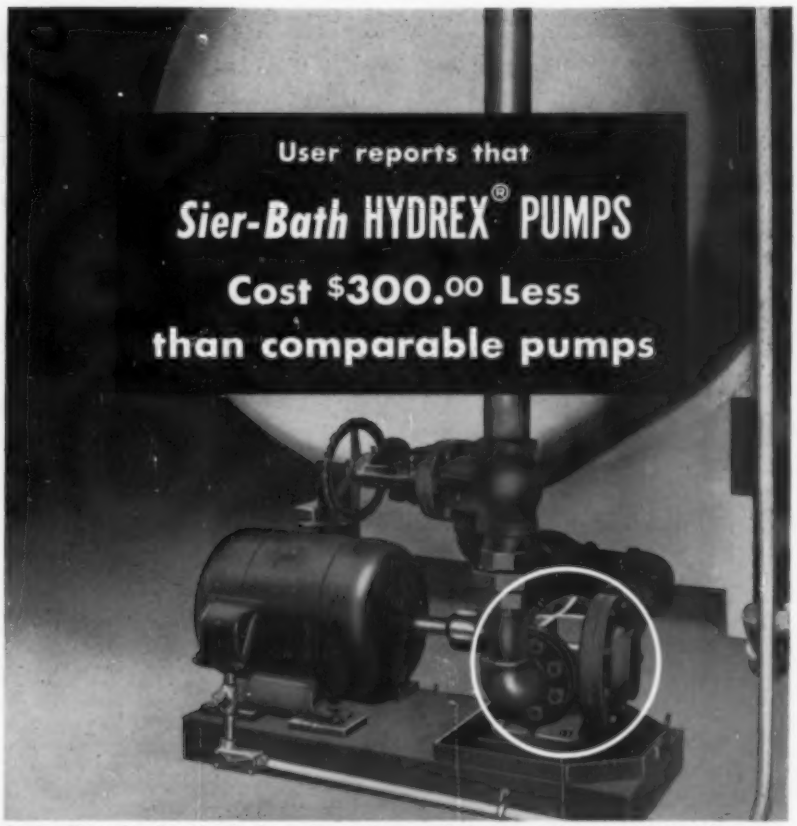


Two new lines of high vacuum pumps, one of oil diffusion pumps and one of booster pumps, have been introduced recently by F. J. Stokes Machine Co., Philadelphia.

Featuring a new design concept, called the "Ring-Jet," both lines have greatly increased pumping capacity over the critical pressure ranges, and will exhaust to substantially higher fore-pressures. The increase in pumping capacity with the "Ring-Jet" is claimed to be more than 50 per cent.

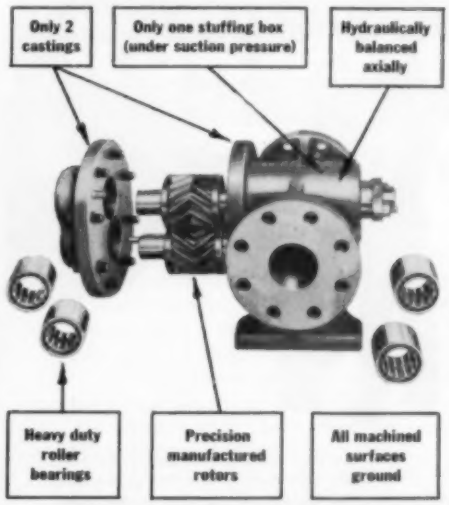


Latest entry in the 100-plus octane derby is Houdry's Iso-Plus Reforming Process. Designed to make 100-plus octane gasoline from low-octane naphthas, pilot plant runs have produced 86%, 87% and 91% conversion of naphtha feed-stock to 100-octane clear gasoline depending on which of three schematic variations were used.



Cosden Paint Co., Beverly, N. J., custom paint manufacturer, uses Sier-Bath "Hydrex" to pump 15,000 SSU resin from storage to plant at 1150 RPM. Cosden reports that the "Hydrex" cost about $300.00 less than comparable pumps . . . does a very good job of pumping . . . has less parts, fewer lubricating points, and requires less space.

Sier-Bath HYDREX PUMP


Only 2 castings
Only one stuffing box (under suction pressure)
Hydraulically balanced axially
Heavy duty roller bearings
Precision manufactured rotors
All machined surfaces ground

The simplest heavy duty gear pump made! Use it in place of pumps costing much more . . . for handling chemical solutions, fuel oils, lube oils, hydraulic liquids, etc.

The "Hydrex" needs no costly speed reducer—can be direct-connected up to 1800 RPM. Extreme simplicity allows heavier construction, easier installation and maintenance, less downtime, longer life.

Models available to pump liquids from 32 SSU to 250,000 SSU, at 1 to 350 GPM, up to 500 PSI. Call your local Sier-Bath Pump Representative . . . write to *Sier-Bath Gear & Pump Co., Inc., 9272 Hudson Blvd., North Bergen, N. J.*

Sier-Bath ROTARY PUMPS

Screw Pumps Gearex® Pumps Hydrex® Pumps

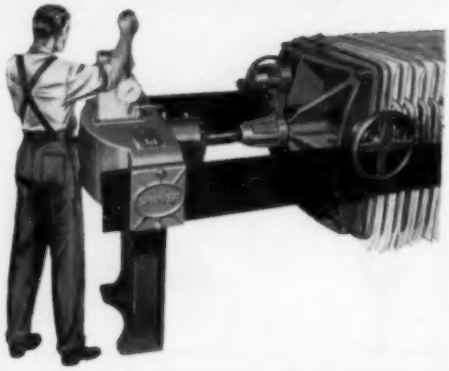
50th Anniversary Mfrs. of Precision Gears, Rotary Pumps, Flexible Gear Couplings Member A.G.M.A.

more catalyst supports
to choose from
Even if your catalyst carrier problem is unique, you're very likely to find its solution among the more-than-two-dozen types of support offered by CARBORUNDUM. These include seventeen different compositions in aluminum oxide, silicon carbide and silica materials as polysurface, spheroidal and cylindrical pellets, and as solid, homogeneous grain. All are highly refractory and inert to most acids. For free kit of samples, write on your letterhead (otherwise only literature will be sent) to Refractories Division, Dept. 155.
CARBORUNDUM
Registered Trade Mark
Perth Amboy
New Jersey

Install **HYDRO-KLOSERS**

on Your

Filter Presses and SAVE



The Hydro-Kloser is a low cost, compact, rugged hydraulic closing device that eliminates time loss and hard labor inherent in manual closing of filter presses. A few easy strokes of the hand lever on the pump bring the pressure to complete tightness of the filter press. This takes but two to three minutes. Opening the press is just as speedy.

The more uniform, more powerful thrust of the Hydro-Kloser assures better closure; minimizes leakage difficulties; saves time per filtration cycle.

It pays to be safe and to save with Hydro-Klosers. Get the full story. Write for bulletin.

This low cost closing unit, easily installed on existing Shriver and other make filter presses, consists of a simple hydraulic ram operated by a small, sturdy hydraulic pump. The ram assembly is mounted on the inside face of the screw standard, replacing the regular screw bushing. Standby manual closing is always available.

T. SHRIVER & COMPANY, INC. • **812 Hamilton St., Harrison, N. J.**

Filter Presses · Filter Media · Diaphragm Pumps

Sales Representatives

Merco Centrifugal Co. San Francisco 7, Calif.
Process Eng. & Equipt. Co. St. Louis 19, Mo.
The Watts Co. Houston, Tex.
Richardson Agencies, Ltd. Montreal, Que.

INSTITUTIONAL NEWS

Chemical engineering graduates were highest paid in a year when starting salaries for engineers again reached a new high.

In a survey of its graduates, Illinois Tech, Chicago, indicated that chemical engineers rated an average starting salary of $398/month, and the over-all new high was an average of $383/month.

The climate of America today is not conducive to the growth of creative scientists, without whose constant work we cannot advance.

This was the conclusion of C. A. Thomas, president of Monsanto, delivering the annual Arthur Dehon Little Memorial Lecture at MIT on April 12. Basing his talk on the necessity and great potential of cooperation between the theorist and the applied scientist. Thomas analyzed the great danger facing the country today—discouraging and thwarting the creative scientist who must think along new and often different paths.

Anti-intellectualism and our people's increasing insistence on the practical applications of all thought, are tending to frustrate many scientists and their work. In fact, Thomas pointed out, scientists today may be becoming victims of a scarcely conscious uneasiness which could stultify their creative powers.

Only in a union of unhampered theorists and the more practical technologists, will come the most flourishing and vigorous growth of creativity in our history.

Plans for the construction of **a new four-story addition** to the chemical engineering building at Case Institute were announced recently. Case expects that the new building will provide much needed class and laboratory space sufficient to relieve the pressure of increased enrollment and to help ease the present shortage of engineers in the Cleveland area as well as the rest of the country.

Joint meeting of the **Midwestern Conferences on Solid Mechanics and Fluid Mechanics** will be held at Purdue Univ. on September 8, 9, and 10, 1955.

Papers are invited in the fields of kinematics, dynamics, vibrations and waves, mechanical properties of materials, stress analysis, elasticity, plasticity, fluid mechanics and thermodynamics.

Information on the conference and the submission of papers can be obtained from the Division of Engineering Sciences, Purdue Univ.

While **Government support of research and development** will drop in 1955, this will be counter-balanced by an up-swing in business support. This was the conclusion of the Fourth Scientific Manpower Conference at Berkeley, Calif.

The two speakers, R. H. Ewell, National Science Foundation, and A. L. Lyman, California Research Corp., showed that Government appropriations will drop to $1,993,000,000 in 1955 after reaching a peak of $2,225,000,000 in 1954, and that industry will finance $1,850,000 worth of research itself in addition to handling $850,000,000 worth of Government research on contract.

It's a seller's market again this year for the graduating engineering student. Stevens Institute, with **128 graduates and 170 companies bidding for them,** some with more than one opening, expects no trouble in placing all its students long before graduation rolls around.

Salaries, too, are still climbing. An average starting salary of $370/month is expected this year with some offers running as high as $440 and over. This follows the trend of the last five years ever since the shortage of engineers became apparent.

Of last year's 119 Stevens graduates none ended walking the streets and not one had to resort to an agency to find a job. Although Stevens grants the degree of Mechanical Engineer, its graduates are working in every major branch of engineering.

It all adds up to another good year for budding engineers.

A possibly valuable addition to the chemical engineers library has been published recently. **A list of master's theses in science, 1952,** the book lists 970 theses in chemistry and chemical engineering.

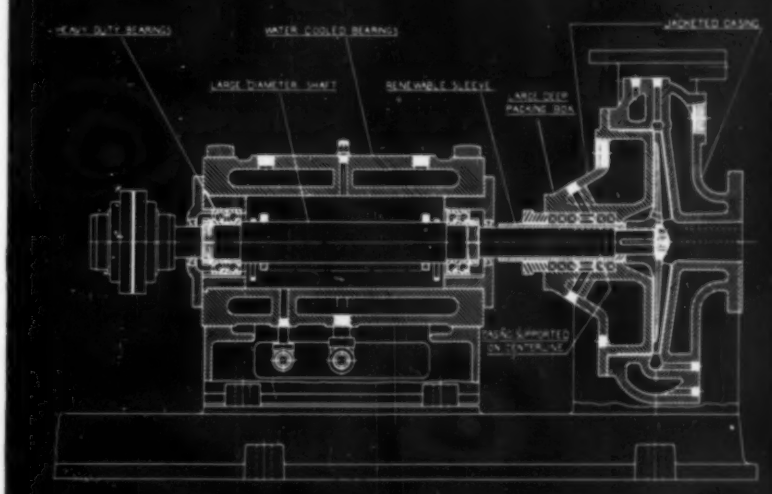
Entitled *Master's Theses In Science, 1952*, the book is the work of Barton Bledsoe and was published by the Biblio Press, Washington, D. C. It has 252 pages and sells for $7.

Theses are listed under the title, with the name of the author and the institution involved. Titles are sufficiently descriptive to give the basic contents.

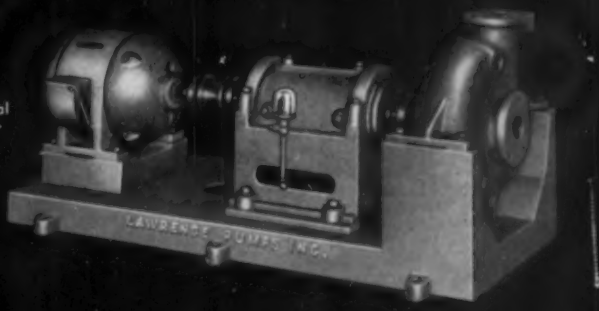
Four-week course in radioisotope training is being given by the Atomic Energy Commission at Oak Ridge to 32 foreign scientists and technicians from 21 nations.

Nations represented are: Australia, Canada, Chile, Colombia, Cuba, Egypt, Finland, Germany, Greece, Guatemala, India, Italy, Japan, Mexico, Netherlands, Pakistan, Peru, Philippines, Spain, Thailand, and Venezuela.

Cross section of Lawrence Horizontal Jacketed Pump



Lawrence Steam Jacketed Chemical Pump with Water Cooled Bearings



HORIZONTAL

jacketed PUMPS

Lawrence jacketed pumps are designed to pump liquids such as sulphur, phthalic anhydride, resins, waxes, etc., which tend to solidify or become viscous at low temperatures. The heating medium can be steam, dowtherm, etc., and all heating spaces are vented and self-draining.

The bearings are heavy-duty, water-cooled. Misalignment and distortion, which might be caused by thermal expansion, are eliminated by supporting the casing along the center line of the shaft.

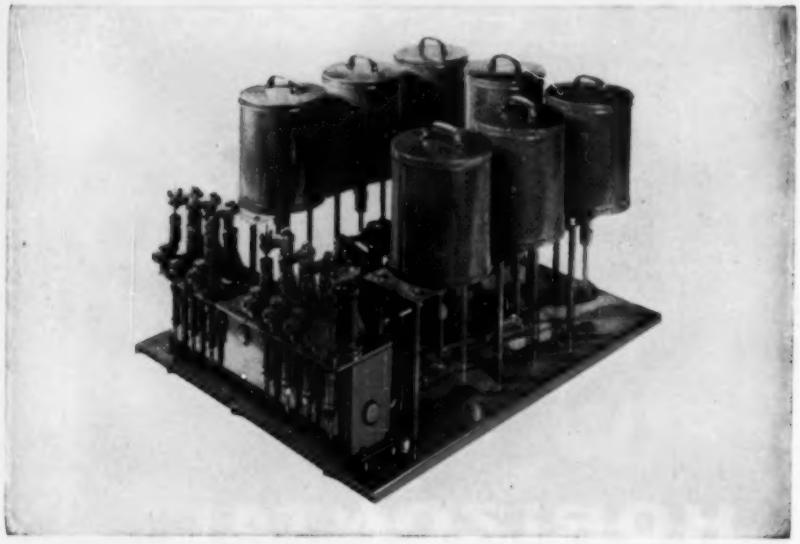
If you have to pump liquids which must be held above a specified temperature to retain their fluidity, write us the pertinent details. No obligation.

Write for Bulletin 203-7.

LAWRENCE PUMPS INC.
371 Market Street, Lawrence, Mass.

Is Foam Troubling You?

MANZEL CHEMICAL FEEDERS CAN STOP IT!



✱ In chemical processes where foaming is a problem, Manzel engineers have a record of successfully eliminating it through the use of Manzel Chemical Feeders. There are models of large and small capacity—for simultaneously feeding many different chemicals at rates from a few drops to 60 gph per feed. They are easily synchronized with any process — supremely accurate and dependable in service.

Specialists, too, in Force Feed Lubrication

Manzel Force Feed Lubricators can be depended upon to deliver exactly the right amount of lubricant, to exactly the right places, at exactly the right times. Available for operation against discharge pressures of up to 30,000 P. S. I. G.

Manzel

DIVISION OF FRONTIER INDUSTRIES, Inc.
352 BABCOCK STREET, BUFFALO 10, NEW YORK

Financial assistance for a limited number of engineers to attend the Ninth International Refrigeration Congress in Paris, August 31 to September 8, is being provided by the National Science Foundation.

Applications should be sent to the Foundation in Washington. Closing date is July 15.

A three-week summer program on "Food Technology" at MIT will review basic facts and consider important recent scientific developments in the food industry.

Scheduled from June 20 through July 8, details and application blanks can be secured from the Summer Session Office, MIT.

Work on the **properties of matter at very low temperatures** has increased at such a striking rate since World War 2 that MIT will devote its **two-week summer session** to "Low Temperature Engineering and Research." Purpose of the program: to acquaint engineers, physicists, and chemists with results to date, low temperature techniques and machines, trend of recent experiments.

Conducted by members of MIT faculty, the session will include many guest lecturers in the field, notably such men as F. G. Brickwedde, chief of Heat and Power Division of National Bureau of Standards; Barnett F. Dodge, Yale chemical engineering professor and A.I. Ch.E. president; and V. N. Kirvobok, International Nickel.

Registrants may live in MIT dormitories. Full details can be secured from MIT's Summer Session Office.

A unique opportunity for aspiring engineers to learn the atomic energy field at first-hand is offered in M.I.T.'s **Engineering Practice School** at Oak Ridge.

Operating at the Gaseous Diffusion Plant, the Electromagnetic Plant, and the Oak Ridge National Laboratory, the school provides education in the practical application of basic fundamentals to technical problems encountered in industry in the areas of research, design, development, and production. Fields covered are chemical engineering, nuclear engineering, chemistry, mechanical engineering, physics, metallurgy, and related fields.

Giving an 18 week term from September through January, and from February through June, the cost is the same as one term's tuition at M.I.T., credit equivalent to one semester of graduate work, and the course is open to graduate students in the appropriate fields.

FIRST FIVE YEARS

—THE CRITICAL PERIOD

Industry's essential need—A loyal, efficient and aggressive working organization.

Crucial point—First five years on job, methods of orientation and training used in those five years.

Orientation and training of engineers for modern industry moved into the spotlight at the October 28-29 Annual Meeting of the Engineer's Council for Professional Development. A feature of the continuing ECPD program, "The First Five Years of Professional Development," the session on training heard five "men-in-the-know" present the problem and its solution in detail.

Speakers were: E. G. Huck, Cincinnati Gas & Electric; C. B. Hedrick, Procter & Gamble; D. F. Pratt, Cincinnati Milling Machine; and J. S. Alford, General Electric. Moderator was J. C. McKeon, Westinghouse.

Starting point for both employers and engineer-employees is basic fact that training begins the instant a man takes his first job, often before—in the first interviews. Habits form the first day on a job, habits that will largely determine the engineer's success and the company's future progress and efficiency.

Second fixed point of departure: All five speakers, and the assembled engineers, agreed that training is a necessity, and not simply mechanical indoctrination of proper technique.

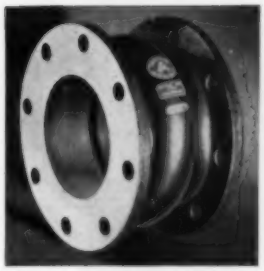
Work Not Watch

Give them real work, productive work, right from the start. The budding engineer will develop neither technique, initiative, management ability, practical experience, or a sense of teamwork and accomplishment by sitting on the sidelines being "trained" by watching. He must get in and pitch on a real, practical problem that will affect actual operation. Only in this way will he develop the needed skills and attitudes necessary for him and for the company.

It is important to proper training that the young engineer be recognized as a professional employee, with a job to do and the education to do it. Too often he is treated as a somewhat annoying hindrance to operation who must learn all the jobs no one else wants and which he will never have to perform again. To treat him as an "office-boy" while he is being trained "off-the-job," is to waste his time and the company's.

A challenge is essential to the man on his first job, and it is essential to the company that the new man be tested

(*Continued on page* 90)



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Rectangular-type Rubber Expansion Joint

U-type Rubber Expansion Joint

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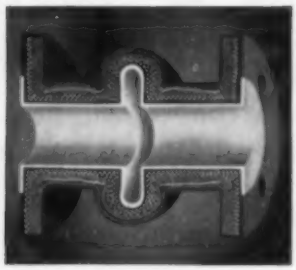
All-Teflon* Expansion Joint



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Garlock manufactures a *complete* line of expansion joints specifically designed to meet the requirements of different types of service. **Rubber Expansion Joints** are made in all pipe sizes from ¾" to 72" for water, air, or exhaust steam. They are furnished in round, rectangular, tapered or offset; spool-type and U-type.

All "Teflon" Joints or **Rubber Joints with Teflon liner** are made for chemical service; **Neoprene Joints** for oil service. Specially designed Rubber Expansion Joints are now available for use on piping and flanges made by **Haveg Corp.** and **The Duriron Co., Inc.**

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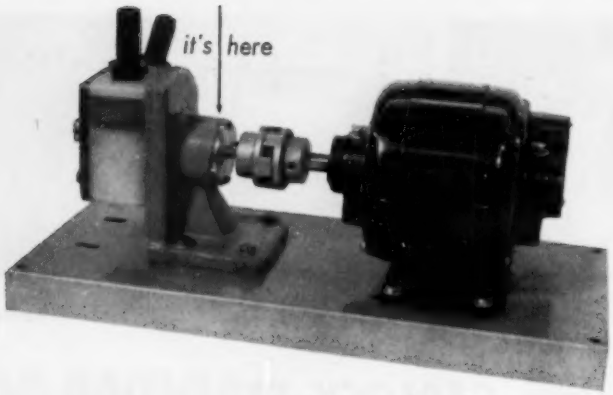

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The Vanton corrosion resistant "flex-i-liner" self priming rotary type plastic pump is available in a new design that permanently protects all bearings from fumes or chemical attack.

Low maintenance is assured since shaft bearings are external and the rotor assembly is stainless steel. Only wearing part is the quickly replaceable low cost flexible liner.

Capacities range from fractional to 5 gpm with 0-50 psi discharge pressures . . . Vanton XB will develop vacuum up to 26″ Hg. and will handle corrosive liquids, gases, viscous fluids or abrasive slurries.

The unique design of the XB isolates the fluid from all actuating mechanisms or rotating parts. Pumping is accomplished by a rotor mounted on an eccentric shaft, creating a squeegee action on the fluid. Displacement is positive and non-agitating.

Wide selection of body block and liner materials makes Vanton XB suitable for an endless list of chemicals, pharmaceuticals and food products. Body blocks are available in: Bakelite, polyethylene, Lucite, Buna N, PVC, and stainless steel. Flexible liners are available in natural rubber, pure gum rubber, neoprene, Buna N, hycar, hypalon and silicone.

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(*Continued from page* 89)

from the start for his ability to carry a responsibility, handle a burden, and produce. For the new engineer—a sense of accomplishment. For the company—a knowledge, learned as quickly as possible, of just how good the man is.

The Who and What

Possibly most important factor in the first five years of training is the trainee's boss. The right supervisor can make or break the trainee. His is the example the new man will follow, his is the advice that will be heard, his is the attitude toward the company and the profession that will be strongest. The methods the boss teaches will be those the trainee adopts, the supervisor's work habits will tend to become the trainee's.

Important to remember is that the best producer, the best technical man, is not necessarily the best teacher. Initially it is vital to have a man as supervisor who is both a good man at his job and a good teacher.

In the early training of an engineer it is good to make his experience as broad and varied as possible, move him around, give him the feel of the company. But it is equally important that this method be selective, that the trainee be placed in positions where the experience will be what he really needs. Regimentation should be avoided both in the sense of a rigid, narrow training in one thing, and in the sense that all trainees should not be forced through the identical paces regardless of what they will be doing later or who they are.

Evaluation and Follow-Up

Both the training program and the trainee's progress in that program should be evaluated frequently. This is not an easy task but if the best results are to be gained it must be done.

Follow-up training, in the form of special courses given by the company itself in specific techniques of the engineer's job after the first five years, is a powerful aid in professional development. In addition, refresher courses, special extension courses, etc., given by universities and colleges are valuable as further training. In this connection, most of the speakers felt that pre-employment academic work should be basic and fundamental rather than specific; the teaching of theory instead of application which could be obsolete by the time the student joined his company.

Perhaps the greatest part of follow-up training should come in the area of management and supervisory techniques, preparing the engineer for future roles

(*Continued on page* 92)

SUGAR

Now By Continuous Diffusion

New, cheaper process giving more and better juice, claims process designer National Cylinder Gas Company.

First significant change in sugar cane extraction for over a century, says company.

What is claimed to be the first successful continuous diffusion of sugar cane is being demonstrated in a pilot scale operation of the Fellsmere Sugar Producers Association at Fellsmere, Florida, by National Cylinder Gas Co., designers of the process and equipment.

After four years of intensive research, National Cylinder has taken the wraps off its process, makes strong claims.

Capital investment: Less than one half that of a mill train of equal daily capacity, less than one half the weight of steel to construct.

Maintenance: National Cylinder claims, from pilot plant indications, a possible 75% reduction in maintenance costs over a tandem of like capacity.

Labor Needs: No more than two operators for all stations from cane feed conveyor to cutter, to exhausted cane discharge.

Power: Total requirements from ⅓ to ½ those of a tandem mill of like capacity.

Purity and Efficiency: 97% efficiency guaranteed says National Cylinder and 99% may be possible. Purity is 2 to 3 points increased over mill juice from same cane.

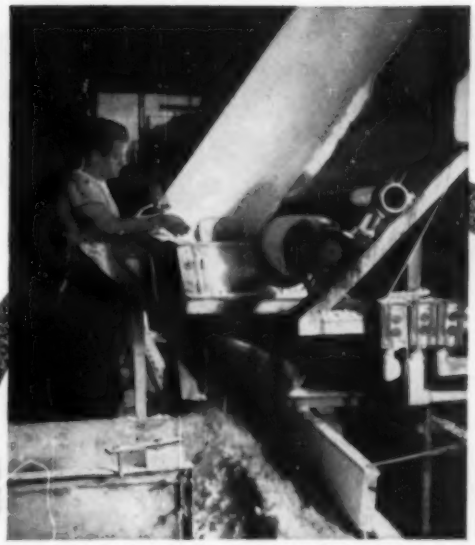
Compact, Efficient

An installation of the continuous diffusion process consists of a cylindrical tower of up to about 10 feet in diameter and about 60 feet in height, together with supporting steel frame. Most of the accessory equipment is supported within the same steel frame. Total area required is about ½ that of a tandem mill of like capacity. All equipment is self-enclosed and needs no building.

Cane is conveyed into a cutter which chops the cane into small pieces roughly ¼ inch thick and the diameter of the cane. From there the cut cane goes to a mixing tank, after being weighed in a continuous weighing device, and is mixed with hot juice from the diffuser. The mixture of juice and suspended cane is then forced into the bottom of the diffuser.

In the diffuser (the vertical tower) a series of slowly rotating helical scrolls carries the cane upward in contact with

(*Continued on page 92*)



Continuous sheet of sticky, dewatered hydrogel, neatly lifted from filter drum at top right, is carried by strings to discharge roll, falls to conveyor.

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(*Continued from page* 91)

the hot water extraction medium. The flights of the scrolls are interrupted periodically to accomodate fixed agitator members that keep the suspended mass of cane in motion and in intimate contact with the extracting liquid.

Water temperature is 190-210 degrees F. and recycled juice used to carry fresh chips into the diffuser is pre-heated to maintain uniform high temperature.

The scroll, heart of the process, is suspended from the top of the tower where the drive motor and gearing are located. Speed is relatively low and no special alignments are involved. Peripheral speeds of scroll are in the range of from 50 to 100 feet per minute. All essential items are electrically interlocked to coordinate their functions.

Basically Chemical

The process which takes place is basically chemical as contrasted to the mechanical crushing and squeezing action of a tandem mill train. Cell walls which confine the sucrose-containing juice are capable of serving as semi-permeable membranes in an osmotic transfer. By a combination of osmosis and dialysis the sucrose-containing juice is replaced in the cane by water, and the water outside the cells carries away the dissolved sucrose.

While the process of diffusion is not new in the sugar industry, being standard practice in the beet sugar part, it is only recently that continuous methods have been employed even with beets, and this is the first continuous process for cane.

Now, National Cylinder is prepared to supply commercial scale equipment and furnish know-how to producers.

Fellowships carrying $1500/yr. plus tuition and fees have been made available in eight fields including petroleum engineering, chemical engineering, geochemistry and chemistry, by Stanolind Foundation, a creation of Stanolind Oil and Gas Company.

Awarded in 15 colleges and universities, the fellowships total 16 in number. No strings are attached to the awards.

(*Continued from page* 90)

of command and leadership. All too often, according to one speaker, a young man is handed a supervisory job out of the blue, having had no training or preparation.

The Best

Today, with engineering manpower as short as it is, it is a matter of simple necessity that a company get the best an employee can give. To do this the crux is training, early training. ECPD, with its First Five Years program is attempting to lead the way to this end. But the program will be worthless unless it has the full backing of industry, the colleges and the professional societies in any given community.

New York, N. Y. Chemical engineering is very much an American development, but interest is growing in Europe based largely on American success in the field. This was the major point of Barnett F. Dodge, A.I.Ch.E. president, speaking at the April luncheon meeting of the New York Section.

Speaking informally about his experiences in France, Spain and Japan, Dodge emphasized that education of the chemical engineer as we know it, based on unit operations study, is still in its infancy in Europe.

At the same meeting, Dodge discussed aspects of A.I.Ch.E. work and present problems. Basic problem is need for money, possible small rise in dues could be in the future.

F. J. Van Antwerpen, A.I.Ch.E. executive secretary, discussed the operations of the society's permanent staff, showing that 75% of finances go into the various publications. Major publications are four in number: *Chemical Engineering Progress, A.I.Ch.E. Journal*, Monograph Series on technical subjects, and Symposium Series publications. In addition the society publishes many miscellaneous pieces, such as industry reports, pamphlets for local sections, etc.

—S. B. Adler

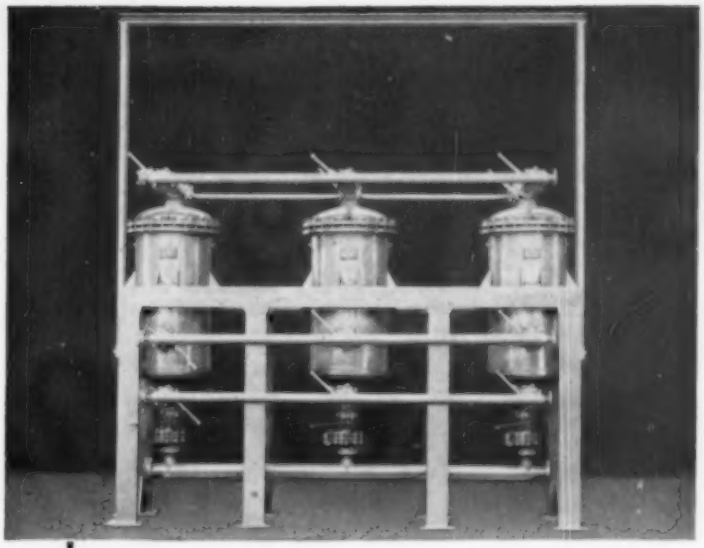
Central Ohio. Data showing that Molecular Sieve zeolites are unusual in having high adsorption capacity at low partial pressure and high temperatures, was presented by R. A. Jones, Linde Air Products, in a paper read at the April meeting of the Central Ohio Section.

In his paper, "Drying of Gases by Adsorption with Synthetic Molecular Sieve Zeolites," Jones spoke of the advantages of the new class of adsorptive dessicants. At 7% relative humidity the Molecular Sieve zeolites have almost 20 wt.-% breakthrough capacity—some five times that of either activated alumina or a gel-type adsorbent.

—R. B. Filbert, Jr.

Detroit, Mich. Riding skip hoists 1150 feet into the earth—this was the beginning of the Detroit Section's meeting of April 7. The meeting, a trip into International Salt's Detroit mine, took the members through a honeycomb of 60 ft. wide passages and 40 ft. high rooms supported by salt pillars. Observing the operations that produce salt from the 98% pure deposits, the Section found the trip a unique and highly informative experience.

—D. W. Anderson



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News of the Field

FROM LOCAL SECTIONS

Rochester, N. Y. What is a professional man? Primarily, says F. J. Van Antwerpen, executive secretary, A.I.Ch.E., he is a man characterized by individual responsibility and specific requirements of training and skill.

Van Antwerpen, addressing the annual meeting between the Rochester Section and the student chapter of the Univ. of Rochester held on March 16th, went on to discuss the various definitions of a professional and the place of organized groups in the life of the professional man.

By examining carefully the purposes of licensing organizations, trade unions, universities, and professional societies, it seemed clear that only the professional societies meet all the requirements for an organization of professional men.

When the meeting considered the ways in which a professional society can represent and help the professional, a lively discussion developed concerning the relation between the professional man and his employer.

—J. Y. Oldshue

Beaumont, Tex. Catalytic reformers present the only feasible means at this time of producing large quantities of automotive gasoline in the 98 to 100 plus octane range. This conclusion was agreed upon by the three members of a panel discussion on catalyst reformers at the April 6 meeting of the Sabine Area Section.

The panel (J. G. Eckhouse, Universal Oil Products; J. A. Nevison, Atlantic Refining; and Norman Feller, Cities Service) discussed the processes of their own companies: Universal's Platformer and new Rexformer, Atlantic's Catformer, and Kellogg's Fluid Hydroformer.

—W. E. Norris

Atlanta, Ga. A sound film on the fundamentals of mixing was shown the March meeting of the Atlanta Section by E. A. Rogers, Mixing Equipment Co. Rogers also demonstrated the various types of mixing.

—H. H. Sineath

Idaho Falls, Idaho. Tracing in detail the flow of petroleum crude through the various separating and processing steps, J. P. Lyon, Phillips Petroleum, spoke on "The Processing of Petroleum" at the March 29 meeting of the Idaho Chemical Engineering Society. The Society has formally applied for recognition as the Idaho Section of A.I.Ch.E.

—Lee Chaison

Philadelphia, Pa. The automatic plant was the subject of E. J. Rosenbaum, Sun Oil, in his talk to the Mid-Atlantic Region Student Chapter Convention on March 25 and 26. The Drexel Student Chapter played host to representatives from nine other universities.

Awards were presented for the outstanding student papers, many of which were read during the session.

—R. H. Feehs

New York, N. Y. There is no such thing as a best all-around distillation tray. With this challenge Raphael Katzen, Cincinnati consultant on distillation, started his task of moderator at the New York Section's March 17th symposium on distillation trays. High interest brought out 200 engineers.

Katzen continued with the statement that the chemical engineer is only interested in obtaining the cheapest column, taking into consideration operating costs, fixed charges and maintenance, for the particular application.

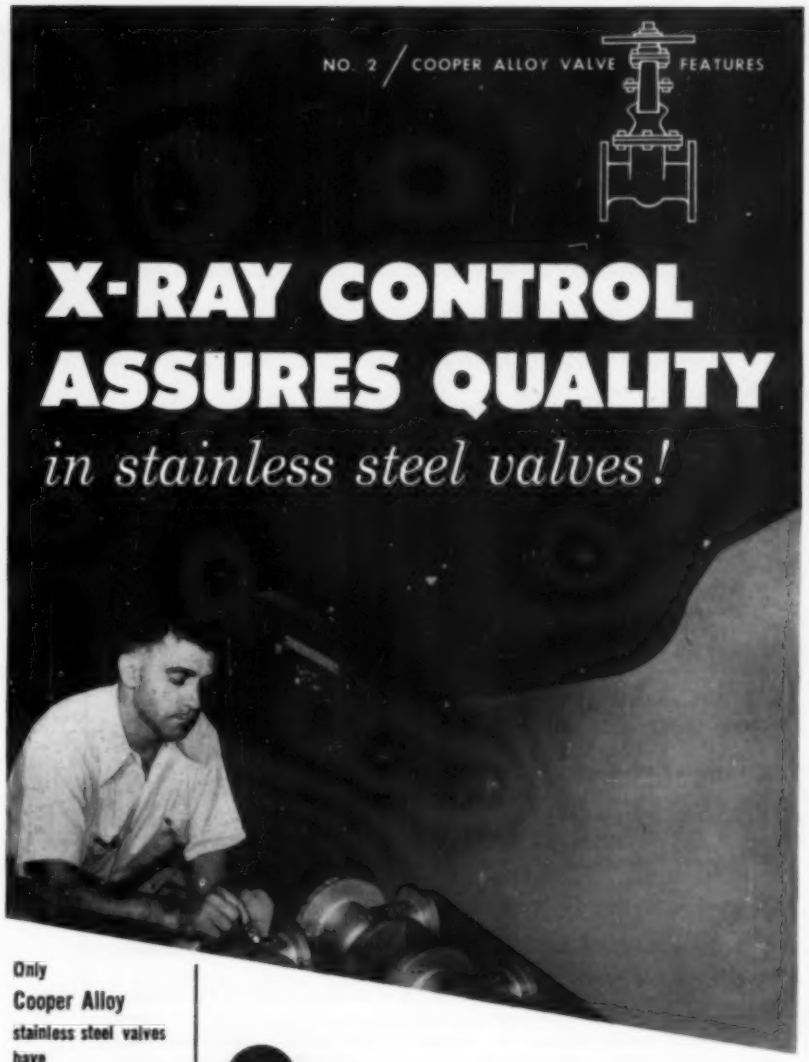
F. A. Zenz of M. W. Kellogg, in presenting a relation for the minimum cost of a tower arrived at by considering the related factors of entrainment, tray efficiency, tray spacing, and tower diameter, indicated that, by comparison with the Souders and Brown relations for maximum allowable velocities, with present minimum cost criteria entrainment values ten times as high may be used.

Describing the performance of Uniflux trays in refinery towers, V. O. Bowles, Socony-Vacuum, stated that recent commercial data showed tray efficiencies about equal to those of well designed bubble caps at 50-60% of the cost.

G. C. Thrift, Koch Engineering Company, illustrated the development and advantages of the Flexitray cap. B. A. Frolov, Shell Development, discussed the applications of the Turbogrid tray which has been used to replace bubble-cap trays when higher capacities are desired in towers, and W. C. Schreiner, M. W. Kellogg, reviewed the development and current status of perforated trays.

—Alfred Krasner

Top (*l. to r.*): Frolov, Schreiner, Bowles.
Bottom (*l. to r.*): Zenz, Katzen, Thrift.



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News of the Field
FROM LOCAL SECTIONS

Boston, Mass. Engineers are too prone to take their job and its problems home with them, said P. K. Munter, M.D., counselling psychiatrist for Harvard and M.I.T. students, in his address to the February meeting of the section.

The world's problems, Munter continued, will not be solved by increased technical progress and the production of cheaper goods. Making this statement in the face of an engineering audience, he added that only by extending our knowledge in the social areas of human development will we overcome our present troubles.

To this end it is necessary to maintain a certain remoteness from one's job so as to keep a proper perspective. One of the best ways to do this is to have an absorbing outside interest beyond the job and the daily routine.

—Ganson Taggart

Univ. of Delaware. Tracing a typical development project from the idea stage, through research, engineering, and final construction in the refinery, H. A. Ricards, Esso Research and Engineering, presented the research and development phase of the petroleum industry to the members of the Student Chapter of the university at its March meeting.

—J. T. McAllister

Philadelphia-Wilmington. H. F. Porter, DuPont, discussed methods of selecting solids processing equipment, analyzed the particular uses of the various types of this equipment, and indicated the criteria of selection at the March meeting of the Philadelphia-Wilmington Section.

C. D. Trombold, Campbell Soup, discussed food processing, with particular attention to the recent advances in the relatively new profession of the food engineer, at the same meeting.

—W. E. Osborn

South Texas. Holding a joint March meeting with the Southeastern Texas Section, the South Texas Section spent most of the meeting on a visit to the rapidly growing Texas Medical School at Galveston.

Later, C. D. Leake, executive director of the Medical School, spoke on the "History of Measurements," emphasizing the continual problem of the battle between the scientist who wants a standard system of measurements, and the trader who prefers different systems which he, the trader, knows and can work with.

—J. H. Presnell

News of the Field

Baltimore, Md. Industry in general has not done as good a job as it could to publicize its efforts in the battle against smoke pollution. This was the major conclusion formed at a joint March meeting of the Maryland and Baltimore Sections.

The meeting, a panel discussion on the subject of industry's stake in a cleaner atmosphere, emphasized that a fair amount has been done to let the public know the importance of the problem in industry's eyes, but so far the efforts have been definitely inadequate.

As an example, the panel disclosed that while 49 firms in the Greater Baltimore area have spent nearly $12 million for air pollution control, this great expenditure is not generally known to the public.

Panelists T. C. Waters, A. D. Brandt, C. E. Smith, H. Williams, and W. H. Weed, moderator, indicated that management attitude in general has been good in that it recognizes the problem, is taking steps to correct existing trouble, and in many cases is building new plants with "built-in" smoke prevention methods.

The panel continued discussion of this important subject by analyzing the methods of determining and controlling air-pollution, and considering the effect of air pollution on health.

—C. G. SCHMITZ

Tulsa, Okla. Time-saving electronic computers (electronic brains) are finding a growing use in chemical and engineering calculations in the research and development phases of the petroleum industry. This was the major development shown in the panel discussion at the March 16th meeting of the Tulsa Section.

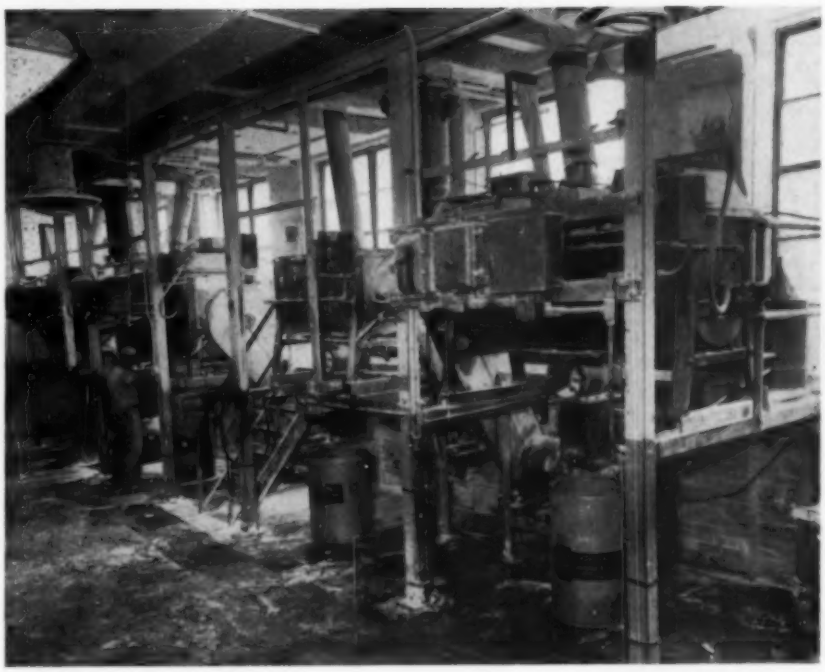
Each expert on the panel presented a different aspect of this general conclusion. Paul Fullerton, partner, Southwestern Computing Service was moderator and gave a general discussion of computers. A senior chemist of Stanolind Oil and Gas, H. L. Pickering, analyzed the application of computers to chemical analyses. The role of computers in chemical engineering problems was discussed by R. O. Shelton, Phillips Petroleum, and D. R. Shreve, Carter Oil, considered their application to petroleum engineering in particular.

—J. H. KELLY

Cleveland, Ohio. The problem of obtaining long term cash, and the current supply of such monies, came under discussion at the January 25 meeting of the Cleveland Section.

Speaker Al Wolf, vice-president of Standard Oil, presented his talk on the financial outlook, and in the discussion period following there were many questions about the current stock market.

—J. L. MILLER



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News of the Field
FROM LOCAL SECTIONS

Charleston, W. Va. The broader aspects of organization are becoming more and more the function of operations research in this country, R. G. Brown of Arthur D. Little, Inc. told the March 15 meeting of the West Virginia Section.

In discussing this complex and somewhat hazy subject, which deals essentially with the human problems involved in any social activity, Brown stressed that while the problems have existed for years only now are quantitative approaches being developed.

Basically the area of operations research involves studying and controlling the human factor to secure maximum efficiency of operation. While the present scientific approach began in England, efforts in this country have veered from the study of efficiency in individual operations to a study of the broader aspects of group operation.

The problem is one of reducing the human factor to a minimum variable by understanding it and, as far as possible, using this understanding to control it and enlist it in productive channels. Nevertheless, the principle of uncertainty remains prominent because it is people who are being dealt with.

—R. W. TIMMERMAN

Knoxville-Oak Ridge. Last frontier for the engineer to industrialize is South Africa, said J. M. Warde, Metallurgy Division, Oak Ridge National Laboratory, speaking before the April 6 meeting of the Knoxville-Oak Ridge Section.

In working this last frontier, engineering methods tend to be American rather than European. But while attempting to industrialize the country, engineers are running into one major problem—water shortage.

Because there are no known petroleum deposits in South Africa, a great deal of work has been done to find other methods of securing oil, with the production of oil from coal by the Fischer-Tropsch process already a major industry.

—R. J. MCNAMEE

Virginia. New uses for various types of plastics in the building construction field were discussed by M. H. Bigelow, Glendale Plaskon Laboratory, Barrett Division, Allied Chemical, at the April 5 meeting of the Tidewater Virginia Section.

Bigelow's talk, illustrated by numerous slides, generally presented the "Plastics in Building" picture.

—G. J. COLI, JR.

FUTURE MEETINGS and Symposia of the Institute

Liquid Metals in Chemical Industry

New Orleans, La. L. M. N. Bach, Tulane U. physiologist, discussing the role of humans in engineering processes before the New Orleans Section, emphasized the importance of the decision-making component to best utilize auxiliary equipment. Human failure in decision-making renders the best equipment worthless, according to Bach.

In working with the problem of the human factor in engineering, teams including an engineer, a psychologist, and a physiologist are assigned the task of designing equipment that will enable the human component to do a better job, he said.

Officers of the Section elected at the meeting include: W. Godchaux, chairman; C. Peters, vice-chairman; W. McWhirter, secretary, and A. Hall, Treasurer.

—E. R. Cousins

East Tennessee. A film, titled "Fluid Mixing," demonstrated the various factors involved in the proper design of a mixer, from both the application and mechanical aspects, to the March meeting of the East Tennessee Section.

Shown by J. A. Mason of Mixing Equipment Co., the firm that made the film, it also analyzed such mechanical problems as shaft critical speed, protection of speed reducer, ease of installation, treatment of stuffing box, etc.

The film is available to any interested section of A.I.Ch.E., and any other qualified organization.

—P. C. Underwood

St. Louis, Mo. The problems and the changing procedures of labor-management arbitration were discussed by Dean Emeritus A. S. Langsdorf of Washington Univ. before the March 15 meeting of the St. Louis Section.

Rather than have a three-man arbitration board, with its all but inevitable 2-1 vote depending how the arbitrator voted, today there tends to be only the arbitrator.

—Aaron Rose

El Dorado, Ark. Explosives technology has advanced rapidly only in the last 30 years despite the seven centuries in which explosives have been known, pointed out C. H. Carlton, Southwest Research Institute, at the March 24 meeting of the El Dorado Section.

Speaking on "Double Base Propellants and Industrial Use of High Energy Materials," Carlton discussed some applications of high energy materials in modern engineering, such as dynamiting, jet perforators, stud, rivet or nail driving into concrete, riveting and metal forming.

—W. L. Break

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FUTURE MEETINGS and Symposia of the Institute

Note: The Author Information column will appear quarterly in the January, April, July and October issues.

MEETINGS **SYMPOSIA**

■ **LAKE PLACID, N. Y.**

Sept. 25-28, 1955. Lake Placid Club.

A meeting devoted to the problems of interest to top management.

NOTE—No general papers

TECHNICAL PROGRAM CHAIRMAN: L. J. Coulthurst, Mgr. Proc. Engr., Foster Wheeler Corp., 165 Broadway, New York 6, N. Y.

Chemical Engineering Organizations of the Future

CHAIRMAN: J. F. Thornton, Pres., The Lummus Co., 385 Madison Ave., New York 17, N. Y.

Growth of the Oil & Chemical Industry by Integration

CHAIRMAN: F. M. Simpson, Vice-Pres., Petroleum Chemicals Inc., 54 Wall St., New York 5, New York

Packaged Power

CHAIRMAN: H. Arthur Martin, Exec. Vice-Pres., J. F. Pritchard Co., Kansas City, Mo.

Deadline—May 25, 1955

Atom Profits

CHAIRMAN: Dr. W. Kenneth Davis, Reactor Dev. Div., U. S. Atomic Energy Comm., 1901 Constitution Ave. N.W., Wash., D. C.

MEETINGS **SYMPOSIA**

■ **ANNUAL—DETROIT, MICH.**

Nov. 27-30, 1955. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. J. Carron, Supervisor, Chem. Eng. Section, Ethyl Corp., Res. Labs., 1600 West Eight Mile Road, Detroit 20, Mich.

Experiences in Nuclear Engineering

CHAIRMAN: R. P. Genereaux, Eng. Dept., Dupont Co., Wil., Del.

Biochemical Engineering

CHAIRMAN: Dr. H. O. Halvorsen, Dept. of Bacteriology, Univ. of Illinois, 362 Noyes Lab of Chem., Urbana, Illinois.

Technical Societies Cooperation with Chemical Engineering Industries

CHAIRMAN: Prof. J. B. Phillips, Dept. Chem. Eng., Phys. Sciences Centre, McGill Univ., Montreal 2, Canada.

Mechanics of Bubbles and Drops

CHAIRMAN: Prof. R. C. Kintner, Dept. Chem Eng., Ill. Inst. of Tech., 3300 Federal St., Chicago 16, Ill.

Standardization of Centrifugal Chemical Pumps

CHAIRMAN: C. J. B. Mitchell, Engineering Service Div., Engin. Dept., E. I. duPont deNemours Co., Inc., Wil., Del.

Evaporators

CHAIRMAN: W. L. Badger, 309 S. State St., Ann Arbor, Mich.

Liquid Metals in Chemical Industry

CHAIRMAN: C. F. Bonilla, Dept. of Chem. Eng., Columbia U., N. Y. 17, N. Y.

Four copies of 100-300 word abstracts indicating as many conclusions and quantitative results as possible, due by May 1, Complete manuscripts invited by deadline even without previous abstract.

Deadline—July 27, 1955

■ **LOS ANGELES, CALIF.**

Feb. 26-29, 1956. Statler Hotel.

TECHNICAL PROGRAM CHAIRMAN: T. Weaver, Proc. Eng., The Fluor Corp., Ltd., Box 7030, East L. A. Station, Los Angeles 22, Calif.

New Techniques for Utilization of Fast Reactions & Freezing of Equilibria

CHAIRMAN: W. H. Corcoran, Cal. Inst. of Tech., 1201 E. Cal. St., Pasadena, Cal.

Current Status of Completely Automatic Process Units

CHAIRMAN: F. C. Brunner, C. F. Braun & Co., 1000 S. Fremont Ave., Alhambra, Cal.

Supervision of Technical Personnel (Panel)

CHAIRMAN: R. D. Gray, Cal. Inst. of Tech., 1201 E. Cal. St., Pasadena

Techniques of Economic Justification for Process Industry Projects

CHAIRMAN: H. E. Wessel, Interna'l. Minerals & Chem. Corp., 20 N. Wacker Dr., Chicago, Ill.

Deadline—Oct. 26, 1955

In order to publish the complete Los Angeles program, future meetings beyond this date will not appear this month. For such information, refer April CEP.

UNSCHEDULED SYMPOSIA

Extraction of Hydrocarbons for Chemical Use from Pipeline Gases

CHAIRMAN: E. E. Frye, J. F. Pritchard & Co., 210 W. 10th, Kansas City 5, Mo.

Fundamental Mechanisms in Boiling Cavitation and Condensation

CHAIRMAN: R. R. Hughes, Shell Development Co., Emeryville, Calif.

Distillation Computation Methods

CHAIRMAN: Wayne C. Edmister, California Res. Corp., Richmond, Calif.

■ **BERKELEY, CALIF.**

June 17, 1955 U. of Calif.

One-day symposium on waste disposal sponsored by Northern Calif. Section, A.I.Ch.E.

FOR INFORMATION CONTACT: T. E. Drisco, 2990 Boni Facio St., Concord, Calif.

Full program appears on page 82, April CEP.

■ **CLEVELAND, OHIO**

Dec. 12-17, 1955. Cleveland Auditorium.

EJC Nuclear Eng. & Science Congress

PROGRAM CHAIRMAN (A.I.Ch.E.): W. K. Woods, General Electric Co., Richland, Wash.

Liquid Metals in Nuclear Power

CHAIRMAN: C. F. Bonilla, Dept. of Chem. Eng., Columbia U., N. Y. 17, N. Y.

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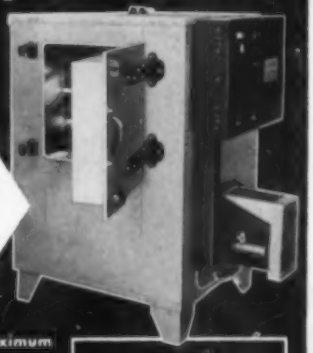

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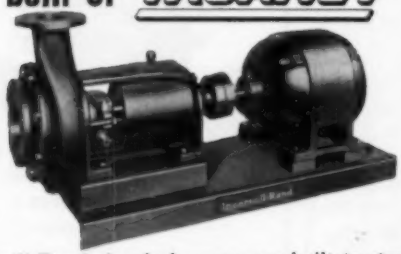

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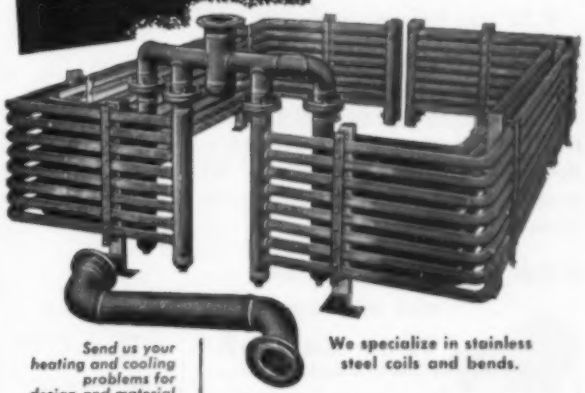

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IN MANAGEMENT AND TECHNOLOGY

William L. Faith, author of a recent CEP article on SMOG, has been elected vice-president and chief engineer of the Air Pollution Foundation.

Faith is a U. of Maryland graduate and earned his doctorate degree at the U. of Illinois. He has extensive experience in chemical engineering having held various positions in business as well as serving on the university level as professor and lecturer.

Besides his CEP article, Faith is co-author of several other engineering publications.

J. Raymond Martin has been promoted to general foreman of the instrument department at Humble Oil's Baytown Refinery.

Martin took his B.S. in chemical engineering at Rice Institute.

C. E. Silling, Jr., joins the research and development division of American Viscose Corp. as product development engineer.

A graduate of Carnegie Tech, Silling holds the first appointment in the newly created product development section of the company. **Albert G. Ruff, Jr.,** is promoted to assistant manufacturing superintendent at the Nitro, W. Va. rayon plant. Ruff joined American Viscose in 1941 with a B.S. degree from the U. of Pennsylvania.

A. Eugene Schubert is named manager-engineering in the chemical materials department, General Electric Co.

Schubert joined GE in 1942 having received his doctorate at Penn State the year before. Among his jobs with the company, he has worked in pioneering research on silicones and the study of Permafils.

Houghton Laboratories, Inc., names **Donald Rice,** chemical engineering graduate of Tri State College, to the research staff.

Victor E. Stilwell is assistant chief chemical engineer in the organic chemicals division of American Cyanamid Co.

Louis Koenig recently assumed the position of vice-president of the Southwest Research Institute, San Antonio, with direction of chemical engineering, minerals, and metals among his responsibilities.

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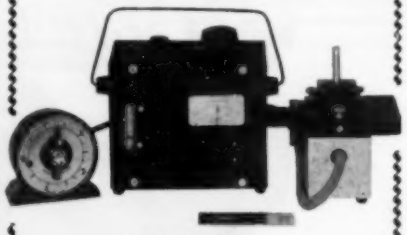

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Hugh C. Land takes over as head of the industrial chemicals division of Pennsylvania Salt Manufacturing Co.

As general manager, Land will direct production and sales activities in the company's distribution and production of heavy chemicals for industry.

With a chemical engineering degree from the U. of Denver, Land began his career with A. S. Horner Construction Co. He joined Pennsalt in 1946 after having served in the Chemical Warfare Service of the Army during the war years.

Land served as field engineer, and production manager as well as in other related positions. He joined the industrial chemicals division as manager of manufacturing in 1954.

Diamond Alkali Co. names **George V. Dupont** manager of manufacturing operations for the recently organized Diamond Black Leaf Co.

Robert C. Sutter is named assistant director of engineering at the company's Painesville, O. plant.

At the same time, Diamond announces **Alexander G. Koos** as technical serviceman in the electrolytic section. Koos is a CCNY graduate in chemical engineering.

John A. Kivlen and **James P. Duval** join staff of Esso Research and Engineering Co.

Kivlen, a Brooklyn Polytech graduate, will work in the Esso engineering department and Duval, a chemical engineer from the U. of Virginia, is assigned to the design division.

T. Q. Eliot moves into position of process supervisor of the synthesis and chemical plants of Stanolind Oil and Gas Co.

Eliot, with Stanolind since 1946, had been senior process engineer in the research department.

Shell Oil Co. names chemical engineers to new positions: **J. M. Wilson,** asst. superintendent of Wilmington, Calif. plant; **A. C. Hogge,** asst. superintendent; **A. J. Wood,** chief technologist, and **S. F. Good,** alkylation department manager.

W. S. Myers, manager of the dispatching department; **J. A. Marshall,** department manager of gas; **R. A. Fischer,** asst. manager of aromatics, and **B. W. Dunbar,** manager of the company's new Anacortes, Wash. refinery. All of the men except Wilson and Dunbar are located at the Wood River, Ill. plant.

(*Continued on page* 104)

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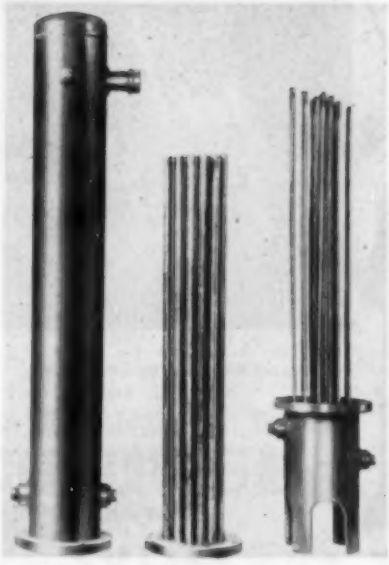

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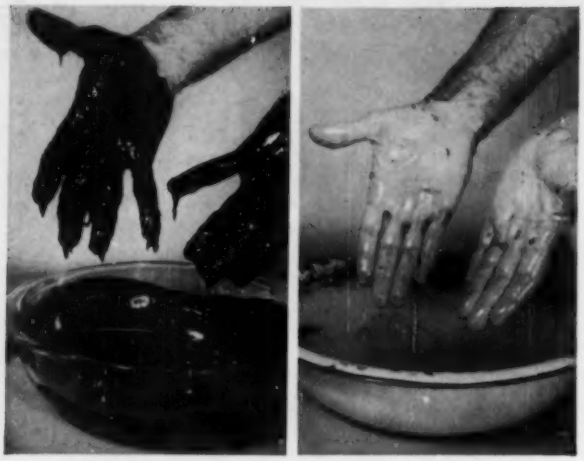

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"Kerodex" provides really effective protection against the many skin irritants encountered in industry. It spreads on like a cream but acts like a glove that is invisible yet strong and as elastic as the skin itself. Does not smear. Does not affect materials handled. Write for full information on "Kerodex"® barrier creams to Ayerst Laboratories, 22 East 40th Street, New York 16, N. Y. 5553

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WHEN YOU'RE 3500 MILES FROM THE FACTORY!

One of ten Nagle 2" type "QW-B," vertical shaft, centrifugal pumps is pictured recirculating spillage to a concentrator at the Paragsha Copper Concentrating Plant of Cerro de Pasco Corp., in Peru. Pump is suspended from chain hoist between guide rails for easy raising and lowering. Fifteen Nagle pumps used at this plant.

The "QW-B" is a wet pit pump with shaft bearings enclosed in a quill. It is as efficient, foolproof and free of maintenance as a pump can be —a good pump to have when you're far from the source of supply. Like all Nagle Pumps, the "QW-B" is designed for abusive service—to handle abrasive or corrosive mixtures, slurries, hot liquids. There's a Nagle horizontal shaft or vertical shaft pump for every abusive pumping job. Ask for Catalog 5206.

NAGLE PUMPS

NAGLE PUMPS, INC.

1255 CENTER AVE., CHICAGO HEIGHTS, ILL.

PUMPS FOR ABRASIVE AND CORROSIVE APPLICATIONS

people IN MANAGEMENT AND TECHNOLOGY

(*Continued from page* 103)

American Lithium Chemicals, Inc., announces **George T. Deck** as plant manager. He had been technical director of American Potash & Chemical Corp., part owner of the new company.

Deck will work with American Lithium in its manufacture of lithium chemicals from lepidolite deposits in Africa, which have been described as the largest known lithium deposits in the world.

George J. Hutzler is manager of engineering research for Spencer Kellogg & Sons, Inc.

Hutzler is responsible for development of new manufacturing processes in vegetable oil operations. He also will direct pilot plant activities in the new research center being constructed.

Previously with Rohm & Haas, Hutzler was graduated from Columbia U. with an M.S. degree in chemical engineering.

Tod Dixon takes over as director of the chemical engineering department of Indiana Technical College.

Dixon was associated for 19 years with Pratt Institute and has industrial and consultation experience including work with Jeffrey Mfg. Co. and Columbia Machine Works.

Roy H. Walters is director of research and development for General Foods Corp.

With the company since 1934, Walters first was employed as engineer in research. He subsequently headed other divisions before his present appointment.

Dupont transfers **Judson C. Rhode** to the technical division of the textile fibers department as technical supervisor.

Rhode will engage in development of new and improved processes for manufacture of cellulose acetate yarn and flake.

He is a graduate of MIT, chemical engineering.

Thomas F. Brastow is promoted to technical consultant to the rayon plant manager, American Viscose Corp. **James E. Corr** succeeds Brastow as technical superintendent at the plant.

people IN MANAGEMENT AND TECHNOLOGY

F. Clayton Nicholson is appointed vice-president in charge of chemical operations of the Davison Chemical Co., division of W. R. Grace & Co.

Nicholson, who succeeds W. B. McCloskey, is responsible for operations in four of Davison's plants.

Before joining Davison in 1942, Nicholson had held technical positions with Anderson-Pritchard Oil Corp. and Gulf Research & Dev. Corp. He is a graduate in chemical engineering of Purdue.

Phillips Petroleum Co. names **Richard Robinson** an associate engineer at the Idaho Chemical Processing Plant, an installation of the Phillips Co.

Vincent A. Walker, Cornell chemical engineering graduate, joins the technical staff of the material testing reactor section also operated by Phillips.

M. Voogd is named manager of the combined butadiene-styrene-copolymer-facilities of Shell Chemical Corp.

D. A. Limerick, former manager of the operations department at the butadiene plant is assistant superintendent, and **M. L. Sagenkahn** is chief technologist at the Torrance plant.

Richard A. Mixer is advanced to manager of protective coatings division, Metalweld, Inc.

Howard F. Kivlin is junior chemical engineer in the engineering division at Foster D. Snell, Inc.

Chemical engineering graduate **Sidney Gottfried** is assigned to product development in paints and varnishes.

CORRECTIONS

Inadvertantly the item in the April issue announcing the appointment of Charles O. Koch as technical service superintendent did not include his company affiliation. Mr. Koch is located at the new isocyanate plant of the Mobay Chemical Co. in W. Va.

N. A. Agapetus was incorrectly announced as having taken the position of chief process engineer in the Texas plant of the Jefferson Chemical Co.

Mr. Agapetus has moved to the technical service division of the company in New York. He had previously held the above position in Texas.

(*Continued on page* 106)

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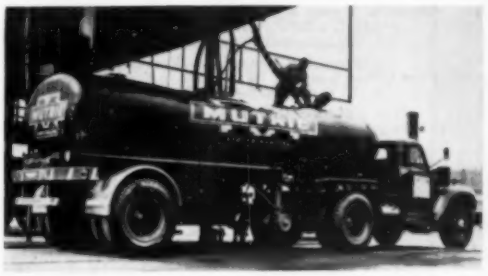
YOU CAN TRANSPORT LIQUIDS
Cheaper and Better in
BONATE PLASTIC TANKS!

Three years of service under adverse temperature and terrain conditions "East of Suez" have proven that the above, lightweight Trailer Tank—one of a group built by us—can haul water, gas and oil better and at less cost than heavyweight predecessors.

Bonate corrosion-resistant Tanks are also delivering the same outstanding service for the country's leading haulers of liquids. The advantages are many . . . let's talk it over!



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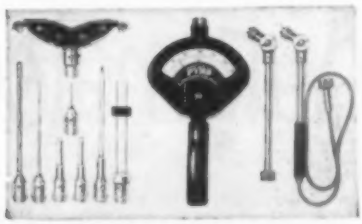

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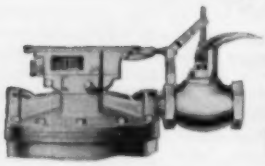
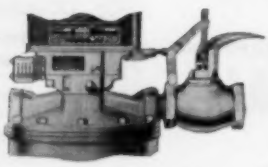
Blends two or more liquids in preset proportions, automatically, in closed, continuous production. Highest possible accuracy. May be integrated with packaging and accounting for automated production. Write for "BLENDING" folder.



Repeating dial delivers predetermined, repeating quantities automatically.



Predetermining dial delivers quantities up to 10,000 gallons, then shuts off.

Recording printer on meter prints quantity dispensed or received for accounting.

BOWSER ESTABLISHED 1885

BOWSER, INC., FORT WAYNE, IND.
1393 E. CREIGHTON AVE.

people

IN MANAGEMENT AND TECHNOLOGY

(*Continued from page* 105)

Gordon Kiddoo is vice-president-development for the National Research Corp., Mass.

A chemical engineering graduate of Cornell, Kiddoo joined the company four years ago and served as director of development for three years of this time.

He has had extensive experience in the field in his previous associations with Hydrocarbon Research Inc., The Texas Co., and Continental Carbon.

P. W. Cornell, with Gulf since 1941, becomes vice-president in charge of operations, engineering, and development.

With extensive experience in synthetic rubber and petrochemical industries, Cornell has worked in several related departments of the company. He is a 1936 graduate of RPI.

During WWII, Cornell remained with Gulf and was assigned to the Neches Butane Products Co.'s technical committee.

With experience as chief engineer and plant manager for Associated Cooperatives, Inc., **Frank A. Faulkinberry** joins the Rust Engineering Co. as staff chemical engineer.

Faulkinberry is a graduate of the U. of Tenn.

Chemical engineers **Harold J. Maddock** and **James F. Dehnert** advance in Tide Water Associated Oil's technology department.

Maddock takes over as chief technologist and Dehnert as assistant technologist.

A. Briggs Bonneville is assistant director of product development for the plastics division of Monsanto Chemical Co.

Clare F. Saltz is manager of the ordnance equipment division of U. S. Hoffman Machinery Corp. Saltz joins Hoffman with 13 years' experience and a chemical engineering degree from the U. of Michigan.

Raymond O'Hara joins Synthetic Products Co. with 10 years of experience in development and application of vinyl stabilizers and metal-organo compounds for the plastic, paint, and grease industries.

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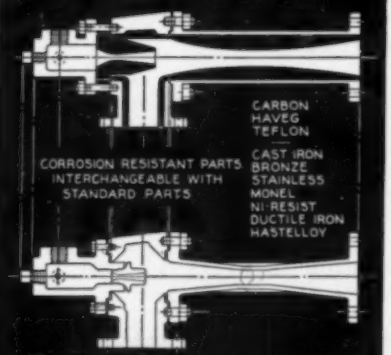

THE JET-VAC CORP.
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the chemical engineer in

MARKETING

Earl Englert is appointed manager of catalyst sales for the gas processes division, Girdler Co.

Englert joined the Institute as an associate member in 1947. He served in the press room for the 1954 Annual Meeting in New York preparing news releases on the event.

Having earned both his bachelor's and master's degrees at Notre Dame, Englert joined Monsanto Chemical Co. in research and then moved to Girdler in 1950. He will have headquarters in Louisville, Ky.

Roger G. Ditzel joins the surfactant sales group of the inorganic chemicals division of Monsanto Chemical Co.

Ditzel will work with customers on the introduction and application of new products and with technical service on surface active agents handled by the group.

He is an Iowa State chemical engineering graduate.

Robert J. Polacek joins sales development section product department, chemical division of the Celanese Corp. of America.

Polacek comes to Celanese from research and market development experience with Wyandotte Chemicals Corp.

A 1951 chemical engineering graduate of the U. of Minn. Tech, **M. W. Ohman** is appointed technical assistant in the sales department of Lithium Corp. of America. Before joining this company, Ohman was sales engineer with Haynes Stellite Co.

James M. McCurdy joins the Detroit sub-office of Dupont's Elastomers division sales force, as technical sales representative.

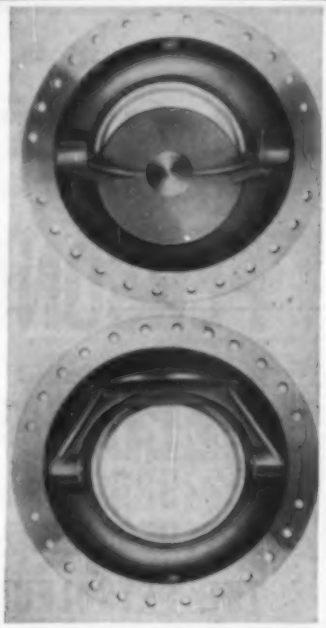
McCurdy earned his chemical engineering degree at Carnegie Tech.

Robert R. Rhodes is assistant manager of sales in the standard pump division of the Worthington Corp.

Rhodes began his service with the company as test engineer in research after graduation with a B.S.ChE. from the U. of Tenn. and five years' military service.

Ralph H. Stalbaum, chemical engineering graduate of the U. of Nebraska, is in charge of the new Union, N. J. sales branch office of F. J. Stokes Machine Co. of Phila.

(*Continued on page* 111)



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Applications should state age and other usual personal data, educational background and qualifications, practical experience, etc. and should include a photograph. Please address personally to the: **Presidente dell'Ente Nazionale Idrocarburi, Via Lombardia, 43—Rome—Italy,** with the special note **RISERVATA PERSONALE** (i.e., to be opened by addressee only).

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CHEMICALS OPERATION MANAGER—Chemical engineer, eighteen years' intensive organic and inorganic operations and development. Record of cost improvements, safety and good personal relations. Registered P.E. Age 39. $14,000 range. Box 9-5.

DR. TECH. SC.—Registered P.E., university professor (Fuels Research), diversified industrial experience abroad, knowledge of several languages. Desire a part-time consultant position utilizing experience (willing to work full-time during vacation time). Experienced in preparation of summaries from German, Russian, and other publications in the field of fuels technology. Box 10-5.

EXECUTIVE CHEMICAL ENGINEER—Eighteen years' rounded technical and business experience process industries. Good organizer and leader. Seek challenging management spot with progressive small to medium size chemical or engineering company East Coast location. Box 11-5.

CHEMICAL ENGINEER-PHYSICAL CHEMIST-Ph.D.—Executive experience. Fifteen years' industrial experience in research and product engineering. Thermodynamics, heat transfer, combustion, fluid flow, refrigeration. Seek new position, preferably west of the Mississippi. Box 12-5.

CHEMICAL ENGINEER—Experienced director and consultant in development and engineering on diversified products. Doctor's degree in 1934, registered engineer, publications, patents. Salary secondary to opportunity. Wants supervisory or administrative position in development, engineering or management. Box 13-5.

CHEMICAL ENGINEER—B.Ch.E. 1952. Age 24, married, draft exempt. Graduate work towards M.Ch.E. Good scholastic record. Three years' experience in process design and project engineering. Desire responsible position with progressive company. Box 14-5.

CHEMICAL ENGINEER, P.E.—Fourteen years' engineering experience, past seven in design and operation of synthetic ammonia plants. Desire position in process or project engineering with progressive company for U. S. or foreign assignments. Box 15-5.

REGISTERED PROFESSIONAL CHEMICAL ENGINEER—M.S.Ch.E. Age 32. Experienced in process development and plant design. Desire opportunity requiring initiative and imagination. Interested in job as consultant or leader of a development effort. Prefer South Atlantic States location. Box 16-5.

CHEMICAL ENGINEER—B.S.Ch.E. 1952. Three years' diversified ammonia plant experience. Desire opportunity in production supervision or process trouble shooting. Married veteran, age 27. Box 17-5.

CHEMICAL ENGINEER—B.E., credits toward doctorate. Experienced in pilot plant design and operation. Plant trouble-shooting and start-ups. Skilled in agglomeration, spray drying, and mixing. Proven ability at handling personnel. Desire supervisory position. New York metropolitan area preferred. Age 33 married. Box 18-5.

CHEMICAL ENGINEER—B.S., graduate work in chemistry and business administration. Six years' diversified experience in fibers and plastics. Age 29, veteran, executive caliber. Desire challenging position with future. Boston area. Box 19-5.

TOP RECORD in B.Ch.E. graduating class of 1950. Five years' development and design experience, mostly in chemical separations aspects of nuclear industry. Single, age 26, occupational draft deferment. Industrious, personable, excellent record and references. Box 20-5.

CHEMICAL ENGINEER—B.Ch.E., age 27, married, veteran. Five years' diversified experience essentially in pilot plant research and development. Desire position in project engineering, R & D, or production. Preferably Philadelphia or New Jersey location. Box 21-5.

CHEMICAL ENGINEER—B.S., Ch.E. 1953. Desire placement as process design or development engineer. Just returning from army service. Served as chief construction draftsman with enginering unit. Age 25. Box 22-5.

CHEMICAL ENGINEER—M.S. Ten years' experience in production, trouble shooting, process improvement, process engineering, and technical and economic studies. Desire responsible position involving process engineering or technical and economic studies. West Coast preferred. Box 23-5.

CHEMICAL ENGINEER-INTERESTED MANAGEMENT—M.S. Eight years' diversified experience process design, petroleum distillation, catalytic cracking, pertochemicals; teaching and production. Prefer position with future in West or Midwest location, but will consider others. Box 24-5.

CHEMICAL ENGINEER—M.Ch.E. Twelve years' experience in soaps, fats and oils, pharmaceuticals and fermentations (design pilot plant and production). Four years' experience in process design engineering. Prefer position in former experience in New York-New Jersey area. Married. Box 25-5.

CHEMICAL ENGINEER—B.S. 1949, age 31, married, family. Three years' process control, some development and production work in processing industries. Three years' rubber and plastic product development work. Material processing and equipment development. Position wanted with a future. Box 26-5.

CHEMICAL ENGINEER—B.S. 1953, age 23, single, completing military service. Desire position with future in pilot plant development or production supervision. Available June 15th. East preferred but not essential. Box 28-5.

Nonmembers

CHEMICAL ENGINEER—M.Ch.E. 1949, B.Ch.E. 1945. Experience in design and engineering, research and development. Desire position as process or project engineer. Single, age 29. Box 29-5.

RETIRING CHEMICAL-MECHANICAL ENGINEER wants part time work. Successful record in devising, designing, building and operating process machinery. Box 30-5.

the chemical engineer in

MARKETING

(*Continued from page* 107)

Robert L. Seitz joins Phila. sales office of American Water Softener Co. as sales engineer.

Seitz brings to his new position sales experience with Cochrane Corp. and Infilco in addition to an engineering degree from Carnegie Tech.

Edward M. Roth, Jr., will assist Albert L. Shutts in the New York sales territory of the Becco Chemical division, Food Machinery and Chemical Corp. He has been on the research and development staff since 1936.

Dow Chemical Co. promotes **W. E. Brown, R. C. Cottrell, Joseph Eveland, F. J. Gibbs, M. Q. Tessin,** and **H. J. Waite** to plastics customer service engineers.

At the same time, **T. C. Broadwell, C. A. Burczyk** and **J. L. Forse** advance to positions of plastics field development engineers. Burczyk has been an A.I.Ch.E. member since 1947.

Koppers Co. names **Robert R. Bench** as sales representative in new Houston, Tex. sales office opened recently by the chemical division of the company.

H. O. Ehrisman is appointed general sales manager for the Foxboro Co., Mass.

L. O. Crockett takes over as general manager of newly formed chemical department of the Gulf Oil Corp. The new department has the specific duty of marketing chemical products for the company.

Crockett had been manager of the petrochemical activities unit and of the technical division, manufacturing department. He has been with Gulf since 1922.

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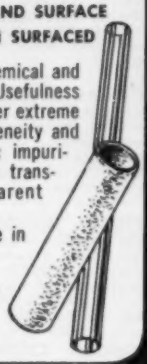

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Necrology

Chemical Engineering Progress has recently been notified of the death of the following people in the field.

Robert D. Pike, 70, consulting chemical engineer.

Widely known consultant in various chemical fields, Mr. Pike won distinction as the inventor of tri-metal bearing used in auto, aircraft and diesel engine design. His development of the Trona and Wyomingite deposits of Wyoming is probably his greatest achievement.

Mr. Pike was a graduate of the U. of California and had been a member of the Institute since 1941.

James L. Howerton, 60, development superintendent, Monsanto Chemical Co.

A graduate of Washington and Lee U. in 1915, Mr. Howerton began his career that year with the Hercules Powder Co. He was considered an expert in the manufacture of hydrochloric and phosphoric acids and related areas of activity.

Richard D. Modrunic, associate engineer, chemical development section, Westinghouse Electric Corp.

Mr. Modrunic had been graduated in 1949 from the U. of Pittsburgh. His working specialty lay in the area of process engineering. He joined Westinghouse in 1953 and has been a junior member of the Institute since that time.

George H. Graham, 36, chemical engineer, Dupont Co.

Mr. Graham had been with Dupont since his graduation in 1941 from Ga. School of Tech., serving in various capacities including production supervisor of the Parlin, N. J. plant.

Scott L. Reeburgh, Jr., 41, asst. supervisor in technical service dept., Gulf Oil Corp.

Mr. Scott joined Gulf in 1935 after his graduation from the U. of Oklahoma. During the war, he served in the Chemical Warfare Service and the Fuels and Lubricants division of the Army. Mr. Reeburgh has been an active member of the Institute since 1947.

G. W. M. Phillips, 67, chemical engineer for U. S. Dept. of Agriculture.

An authority on heat transfer processes in food technology, Phillips directed engineering studies of the recovery of the natural fruit flavors from fruit juices.

Phillips was graduated in 1910 from the U. of Pennsylvania. Besides his work with various industrial organizations including Dupont and American Cyanamid, he served in WWII as director of studies in recovery of natural rubber.

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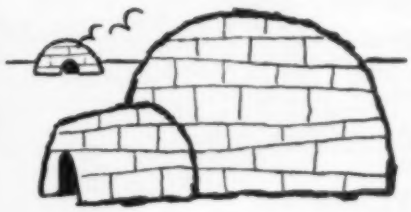

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news and notes

A.I.Ch.E. $ FACTS . . . 75% of the total A.I.Ch.E. income is spent on publications. . . .

FOR EVERY $1 received by the Institute as dues & entrance fees, $1.86 is spent on publications . . . .

FOR EVERY $1 received by the A.I.Ch.E. as subscription income, $3.40 is spent on publications . . . .

NEW A.I.Ch.E. JOURNAL is well underway with about 3,000 subscribers so far.

A. B. METZNER, Professor of Chemical Engineering at the University of Delaware, won the A.I.Ch.E. Presentation Award for the second time . . . At the Louisville meeting he was selected by the judging committee as having presented his paper in the most interesting & polished manner . . . The other occasion on which Professor Metzner won was the Biloxi, Miss., meeting in March, 1953 . . . Improvement in techniques of presenting papers at A.I.Ch.E. meetings is in no small measure due to this presentation emphasis . . . .

JUDGING COMMITTEE HAS difficult and time-consuming job in listening to every paper & evaluating presentations . . . Committee this year is headed by Dr. Clyde McKinley . . . Louisville subcommittee was chairmaned by R. M. Reed.

A.I.Ch.E.'s PART IN INDUSTRY came off with a high score in the questionnaire circulated by the Charleston, W. Va., section on Growing into Management & How Can a Professional Society Help? . . . G. A. Trigaux coordinated the study & a number of questions were asked of the group graduated 1 to 15 years ago . . . What particularly impressed me as Secretary were the answers concerning the Institute & its relationship to management . . . 87% of the group reported that their companies encouraged participation in A.I.Ch.E. activities . . . The same percentage felt that periodic attendance at A.I.Ch.E. meetings helps growth into management . . . 97% felt that the company would benefit by employees' periodic attendance at A.I.Ch.E. meetings . . . .

IMPORTANT IN THESE days of unionization was the fact that only 4% of those who answered the questions favored "a set pay scale by the A.I.Ch.E. for engineers" . . . . Altogether, 50 questions were answered, a summary of which will be published in Chemical Engineering Progress.

NEW "KNOW YOUR INSTITUTE" booklet is ready . . . the work of Ted Burtis of the Houdry Process Corp. . . . This popular book will go into a 10,000 printing . . . all committee personnel, local section officers, etc., will receive copies . . . . Should any other member of the Institute wish a copy, drop us a post card.

TULSA SECTION is going to hold a meeting this month on Improving the Engineer's Ability to Express Himself . . . which brings us to a point of pride that the three articles by Dr. H. J. Tichy, "Engineers Can Write Better," broke our all-time record for reprints . . . Copies are available at 50 cents each.

DIRECTORY SUPPLEMENT FOR 1955 was published last month . . . Members who want this latest listing of committees & officers, accredited colleges, representation with other groups, etc., need only drop a line to this office.

THE MINING ENGINEERS have changed their name from American Institute of Mining and Metallurgical Engineers to American Institute of Mining, Metallurgical and Petroleum Engineers . . . Ernest Kirkendall is the new Secretary, succeeding Edward H. Robie, who is now Secretary Emeritus . . . Another recent retirement in the engineering societies is that of W. N. Carey, Secretary of the American Society of Civil Engineers.

PERSONAL NOTE . . . It is always amazing and heart-warming to me to witness the time and effort given willingly by busy members for the good of the profession . . . One of our committee chairmen forwarded to me the following acceptance, which is being kept anonymous, "I would be willing to serve on the . . . Committee . . . I have always felt that the Institute should participate wholeheartedly with the other Engineering Societies in the matter . . . I suspect it will be quite some time before this issue is settled & would agree that a committee appointed by the Institute at this time should be committed to a rather indefinite assignment as far as time is concerned" . . . that from a very busy man.

F.J.V.A.

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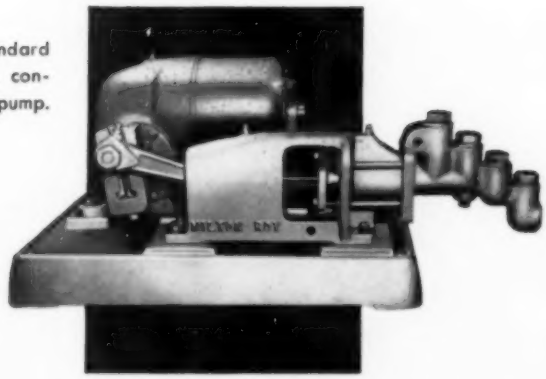

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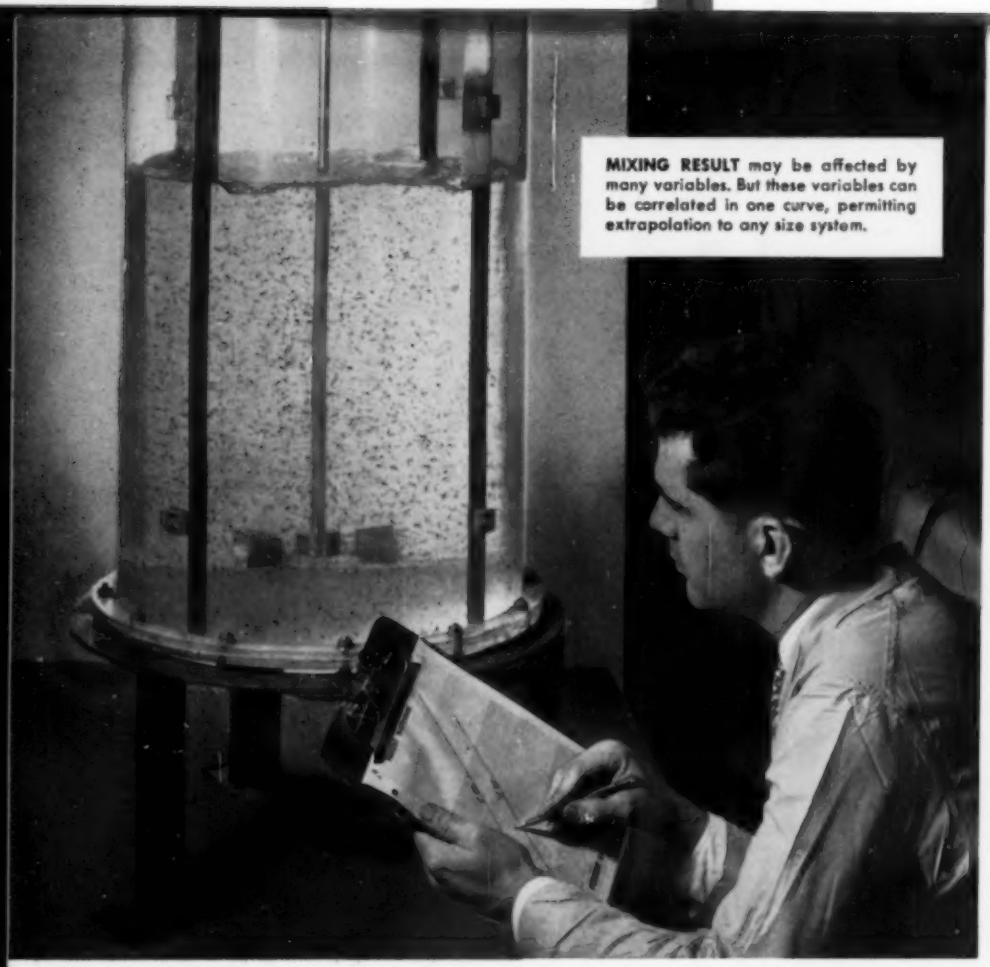

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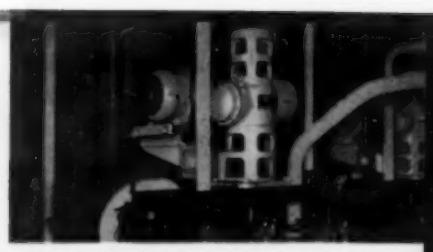

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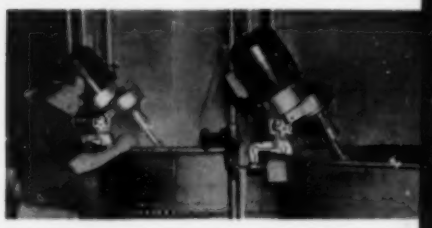

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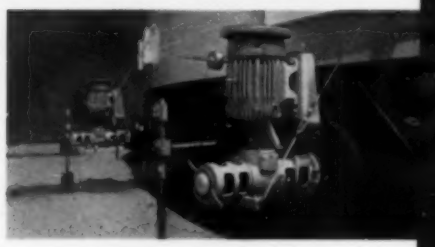

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- ☐ B-103 Top Entering Mixers (propeller types)
- ☐ B-104 Side Entering Mixers
- ☐ B-107 Mixing Data Sheet
- ☐ B-108 Portable Mixers (electric and air driven)
- ☐ B-109 Condensed Catalog (complete line)
- ☐ B-111 LIGHTNIN Rotary Mechanical Seals

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